THE McGRAW-HILL MAGAZINE FOR DESIGN ENGINEERS

OCT 2, 1961

METRIC UNITS?

"... We are at a disadvantage by not using the system of measurement that most ... countries use"—Dr. A. V. Astin, director, NBS.

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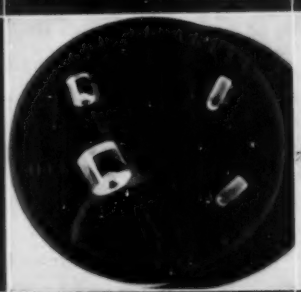
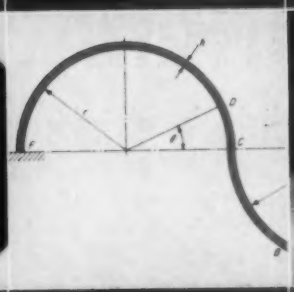
PRODUCT ENGINEERING





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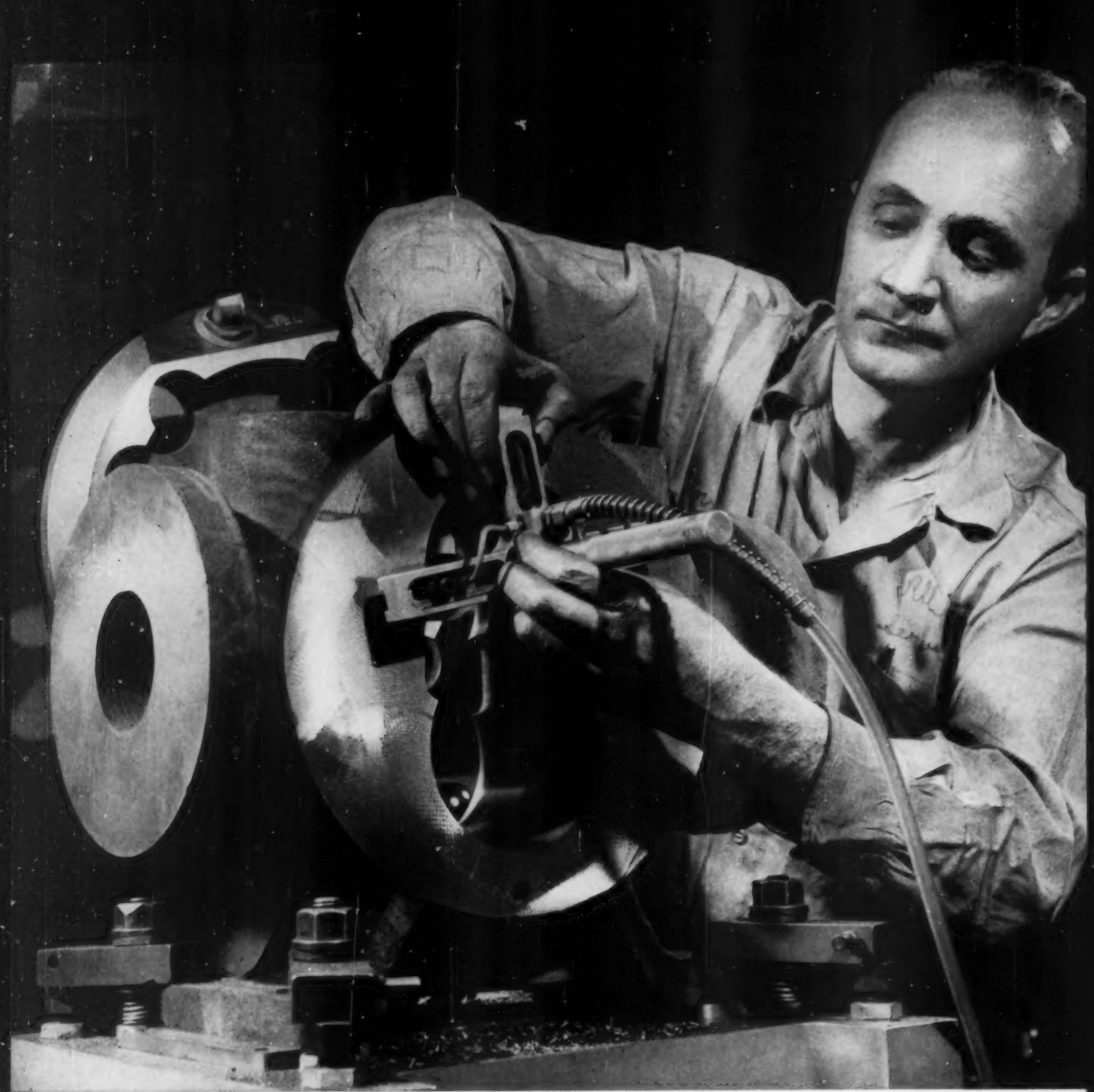

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Close tolerances are extremely important in a rotary pump. Capacity, efficiency, quietness, and low maintenance depends on the accuracy built into the pump.

That's why Worthington has invested many hundreds of thousands of dollars in precision equipment designed specifically for the manufacture of rotary pumps. The air-gauging machine above, for example, checks the interior dimensions of a rotary to an accuracy of one ten-thousandth of an inch.

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For the name of your nearest Worthington pump distributor consult the Yellow Pages. Or write to Worthington Corporation, Section 20-16, Harrison, New Jersey.

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DESIGN NOTES

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Designer Advantages

The CRS Seal gives the designer one, basic, rugged shaft seal design which may be applied with high reliability to the great majority of common shaft seal applications — particularly in industrial, automotive, farm, and off-the-road equipment.

Four basic design variations are available. As you can see, these provide an auxiliary sealing lip, where it may be required, or provide extra rugged shell construction where conditions suggest the need to protect the seal lip against assembly damage — or where large, heavy-duty shafts are being sealed.

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Operating Maximums*

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Run-out	.015" TIR dynamic eccentricity .010" static eccentricity
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Pressure	5 psi (single lip) 10 psi (double lip)
Media	Oil, grease, fuel, water

**Not all conditions present in one application*

New, Improved Compound

Standard sealing members for the C/R Type CRS Seal are molded of a new Sirvene synthetic rubber compound having markedly superior sealing and wearing properties. It is a Buna-N-based material with low-friction characteristics. The CRS Seal can also be furnished in the usual special materials such as acrylates, Silicones, and butyls. Shells are of standard steel, but can be provided in corrosion-resistant materials on special order.

Consult C/R Engineers

For assistance on the application of the new CRS — or on any oil seal problem, get in touch with C/R Oil Seal Engineers. They're specialists in fluid sealing — and will gladly cooperate with you.

For More Design Data:

You will want the complete design data on the new CRS Seal. Write for our Bulletin CRS-100. It gives you the complete list of standard sizes, widths, O.D.'s, shell thicknesses and sealing lip heights. You will want it to compare and then specify C/R's CRS Seal.

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PRODUCT

14 Rules for Cooling with Blowers 39

They're not quantitative—they are simple principles taught by bitter experience. How to choose a blower configuration; how to mount it; how to duct the air and position the cooled components. *A M Wilczenski*

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Don't underrate diamond as an engineering material. It offers many properties no metal or ceramic can duplicate. Look at how well it serves as a miniature bearing and as a relay-contact material. *A G Asaff*

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First time published anywhere—design charts and equations to predict sheetmetal forming failures for 19 materials, 12 processes.

Properties of Glass

More accurate tensile strengths of seven glasses plus a roundup of mechanical properties and how they change with rising temperature.

Which Stress-analysis Technique?

Here are the 7 main categories, from strain gages to brittle coatings, plus selection tables. First of a series.

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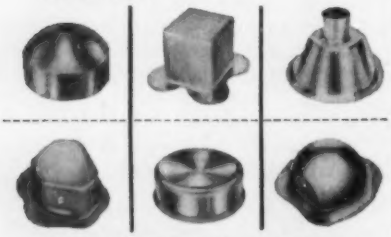

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METAL CRAFTSMEN
SINCE 1924

HORIZONS

F. Haugerman

Bridge and Four Walls

Man has always been particularly intrigued and impressed by largests, smallests, highests, firsts. There was a time when theological arguments revolved around how many angels could dance on the head of a pin, a later one when the Lord's Prayer engraved on a pinhead was the acme of miniaturization. News and international prestige have been made by highest buildings, biggest dams—and currently by firsts in space. And feature writers have wondered at the pages of specs and prints for any complex engineering product—measuring the new battleship or bomber in terms of pounds of blueprints, for example. We have pointed pridefully to our acres of tracings and files.

The tons of paper and bins of replacement parts seem destined for obsolescence as replaceable assemblies and, "drawings" on tape and microfilm take over (*PE—Jan* 30 '61 cover). And high time, too. The cost of drafting has increased so markedly in recent years that it has been estimated at more than 15% of the over-all cost of some mighty expensive and exacting designs.

But our problems are dwarfed by those of ancient Egypt. Macaulay, in "Fragments of a Roman Tale" (*Knight's Quarterly Magazine,* June, 1823), tells this story:

"About four hundred years after the deluge, King Gomer Cheporaod reigned in Babylon. He united all the characteristics of an excellent sovereign. He made good laws, won great battles, and whitewashed long streets. He was, in consequence, idolized by his people and panegyrized by many poets and orators. A book was then a serious undertaking. Neither paper nor any similar material had been invented. Authors were, therefore, under the necessity of inscribing their compositions on massive bricks. Some of these Babylonian records are still preserved in European museums; but the language in which they were written has never been deciphered. Gomer Cheporaod was so popular that the clay of all the plains around the Euphrates could scarcely furnish brick kilns enough for his eulogists. It is recorded in particular that Pharonezzar, the Assyrian Pindar, published a bridge and four walls in his praise."

If you object to your present necessary reading, what would you have done then? And what will you do tomorrow, unless a more practical shorthand is developed for engineers?

Perhaps the solution is already in the making, as the age of solid-state physics dawns. The newspapers recently outdid even themselves in extolling the wonders of complete electronic circuits in tiny wafers and of apartment ice-makers with no moving parts. For such devices, there are few prints and fewer maintenance manuals. One, it seems, does not repair; one replaces. The difficulty seems to be, however, that these devices are quite costly because the component that fails to pass inspection is unreclaimable scrap. And, like miniature vacuum tubes, many fail.

Yet, thirty years ago, US Time had a simple—and similar—test for dollar watches. They were wound and hung on a board. Those that, at the end of the test cycle, were outside tolerance were simply chopped in half; repair cost 54¢ while the original product cost only 39¢. (The Army has recently resurrected this idea in eliminating watch repairmen; it's cheaper to replace $7 wristwatches in the field than to maintain expensive ones, although some attacks may be a bit ragged as a consequence.)

This brings up another philosophy that it will take a new generation to

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I OF A SERIES

NOTES FROM A DESIGNER'S SKETCH BOOK

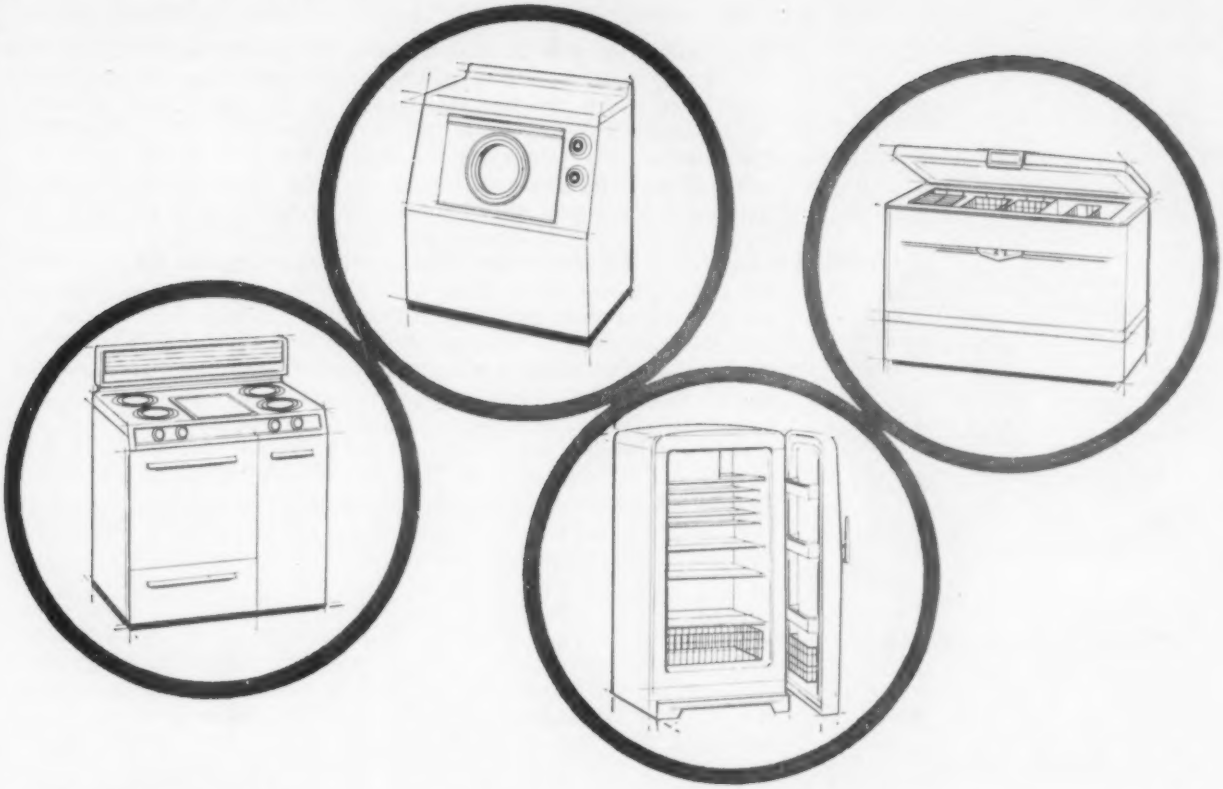

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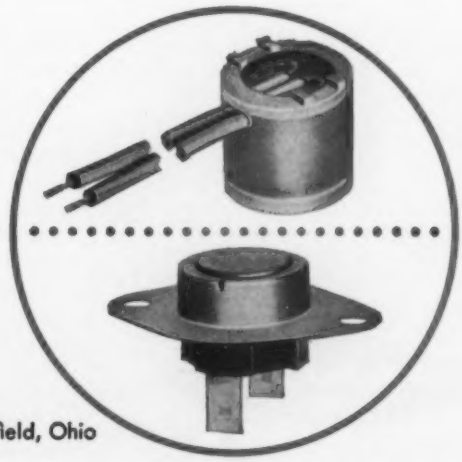
**Table appliances, too:* Skillets, saucepans, griddles, inhalers, fans, steam and flat irons, roasters, fry kettles, butter warmers, waffle irons, electronic and avionic applications.



Stemco Type GP Thermostats, one of a family disc type potted thermostats for moisture resistance. Used on refrigerators, freezers, coolers, etc. Fast response and quick, snap action control.

Stemco Type GY Thermostat, one of a number of similar designs with exposed or enclosed bimetal disc for dryers, heaters, air conditioners and similar applications. Various terminals and mounting provisions.

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HORIZONS *continued*

accept fully. In your youth and mine, the family slogan was usually "Waste not; want not." We turned off lights, picked up and straightened nails, saved string. No one ever considered the cost of time and labor; we still believed that men and time were expendable but physical assets cost money.

I shall never forget the two shocks in quick succession that made me realize our philosophy was changing—the carpenter who said flatly that it cost more for him to stoop to pick up a dropped nail than the nail was worth, and the master mechanic who simply clipped off connecting lugs from machine power leads at the box—again because his time was too valuable to waste in taking off the nuts. (In each case, I found my time was less valuable somehow; I had to pick up the nails to prevent punctures and to salvage the lugs so the machine could be reconnected at its new location.)

Perhaps we're becoming too efficient—too efficient to do what was once a workmanlike job. And time and space are too valuable to keep records in their original form. And with it we're becoming too blasé—unwilling to do the workmanlike job, unwilling to take the real interest that leads to a real job. And so blasé that a bridge and four walls could no longer serve two purposes as they did six millenia ago.

• • • •

An American is a guy who sips Brazilian coffee from an English cup while sitting on Danish furniture after coming home in his German car from an Italian movie—then writes his Congressman with a Japanese ballpoint pen, demanding that he do something about all the gold that's leaving the country. —*Harry Lieberman, comedian, San Francisco*

"A continuous, avalanche-like growth in the number of publications" is causing Russian scientists to spend more than half their working hours trying to keep abreast of latest developments, only 35% in actual experiment, according to the Academy of Sciences, USSR. Traditional theories of bibliography and library science fail to satisfy current requirements; no one of 350 known systems "can be considered satisfactory." Perhaps our best bet for slowing Russian advances is to make all American literature available in the USSR.

People scorn what they don't understand, Congressmen like anyone else. A non-engineer friend waxed quite satirical over the pumped-storage hydro plant idea; the idea of pumping water uphill during offpeak periods so it is available during peaks struck him as ridiculous. But when he learned that the idea began with his Swiss ancestors at least 30 years ago, he listened soberly to an explanation. The Swiss are not foolish or wasteful people . . . *The New York Times* for August 22, however, carried a UPI report on a House Interior subcommittee meeting the previous day. Rep Walter Rogers (D, Texas), chairman of the Irrigation & Reclamation Subcommittee, and co-sponsor of legislation embodying the pumped-storage idea, called it a "Rube Goldberg invention." Rep James A Haley (D, Fla) snapped, "A waste of the taxpayers' money!" Interior Dept men explained the idea, said it would reclaim two of each three kilowatts spent in pumping. Rep Rogers inquired why only 2 kw would come back downhill if 3 kw of water were sent uphill. Says the dispatch, "By this time, most of the committee was roaring with laughter." Engineers for the Bureau of Reclamation explained that pumping uphill and flow down were each only 85% effiicient, that we have a pumped-storage unit at Flatiron Dam in Colorado, that Folsom, Calif; El Paso and Albuquerque in NM; and Casper, Colo, are other possibilities . . . Somehow, we're reminded of the story of Nero, who fiddled while Rome burned.

NEW—TWO LOW-COST MINIATURE BALL BEARING LINES

New Departure ABEC 3* and ABEC 5* miniature ball bearings now offer manufacturers of precision miniature potentiometers, gear trains, motors and similar precision products the opportunity to reduce bearing costs substantially.

New Departure ABEC 3 and ABEC 5 bearings can be used wherever the high precision and performance of ABEC 7 bearings are not required. They offer the engineer greater design versatility—he can select the most economical bearing for each application. Moreover, New Departure ABEC 3 miniature ball bearings can be used to upgrade products presently using precision sleeve bearings.

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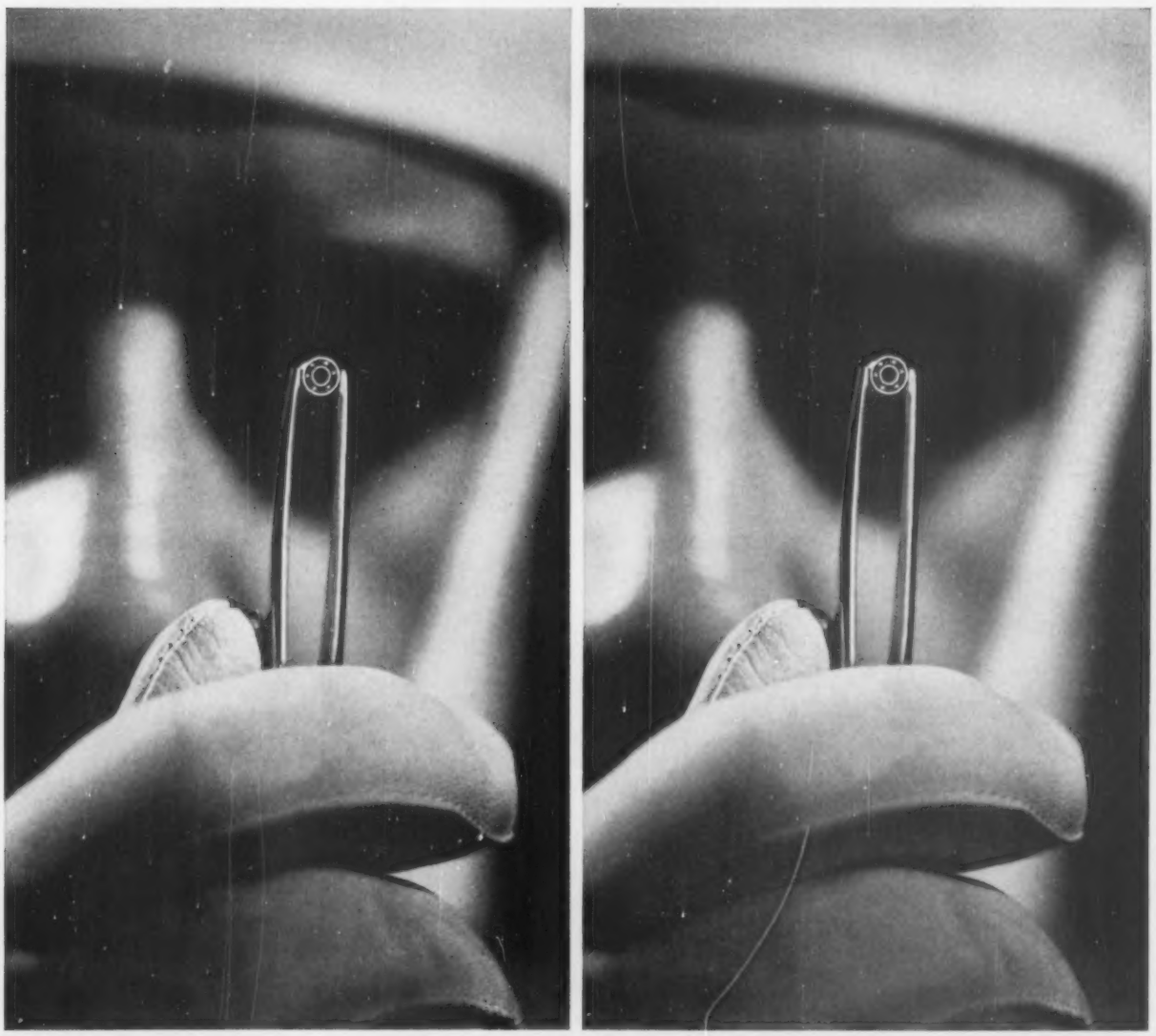
If you are planning a re-evaluation of your miniature bearing applications, it will pay you to consult the N/D Sales Engineer in your area. His assistance may help pave the way to reduced parts cost or enhance the quality of your product. For more information, write for booklet AST, NEW DEPARTURE, DIVISION OF GENERAL MOTORS CORPORATION, BRISTOL, CONN.

*Bearing tolerances as established by the Annular Bearing Engineers Committee of the Anti-Friction Bearing Manufacturers Assoc.



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The truck transmission gear forging at left is an outstanding example of metalworking by the forging process to take advantage of the inherent directional properties of forged steel. Upset forged by Transue & Williams Steel Forging Corporation, Alliance, Ohio, the part has been cross sectioned and etched to reveal grain flow.

In forging, only quality controlled bar or ingot stock is used. Forging (or combination forging and extrusion) achieves grain refinement that produces the best possible material for response to heat treatment. In addition, die design is engineered to orient grain flow in the direction requiring maximum strength.

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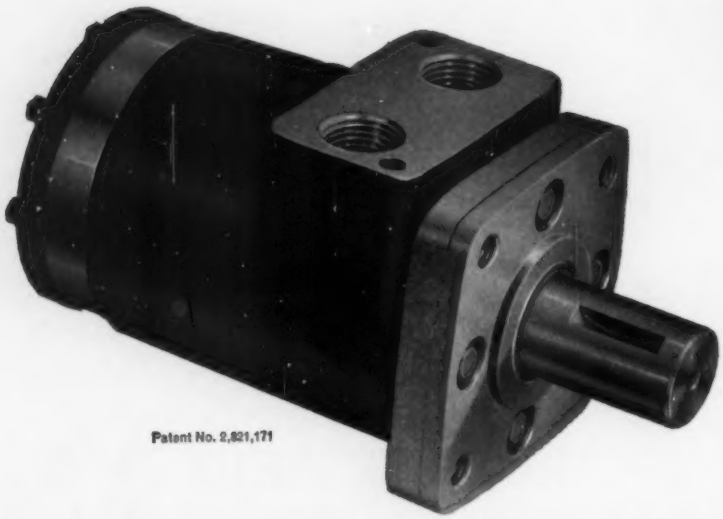

Patent No. 2,821,171

New Char-Lynn Hydraulic ORBIT MOTORS® deliver Full Torque regardless of speed range

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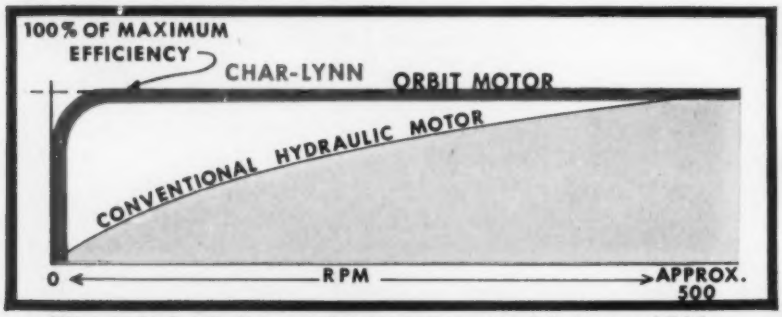

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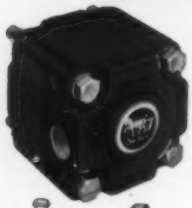
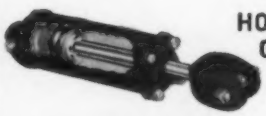


HORSEPOWER PUMP 400

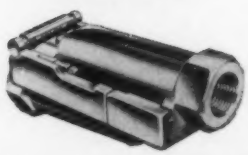
HI-LO POWER PAC PUMP P-400

STROKONTROL CYLINDER C-133



HORSEPOWER CYLINDER C-102

HYDRAULIC FLUID FILTER F-240



HOSE COUPLER H-730

For complete details write Dept. HM Char-Lynn Company • 2843-26th Avenue South, Minneapolis, Minnesota

Char-Lynn

HYDRAULIC HORSEPOWER PRODUCTS

INTERESTING TO NOTE

IN 1714, Queen Anne of England granted a patent for a device to reproduce letters of the alphabet "so neat and exact as to not be distinguished from print." It was the beginning of the modern typewriter.

The man who received the patent, an engineer named Henry Mill, was searching for the solution to an age-old problem. The only method known of keeping daily records and transacting business was to have letters and documents copied with pen and ink by a professional "scrivener." It was a slow method and results were often so sloppy they couldn't be understood. Mill realized that a quick, easy way of putting type on paper was the answer, but he was unable to turn his idea into a working model. However, word of his idea spread and stirred the imagination of other inventors. The next hundred years saw at least 50 more attempts to make the writing machine a reality. Some of the devices even worked—after a fashion. Most were just impractical contraptions.

Then an American named William Burt developed a machine in the early 1820s called the "Typographer." A heavy, boxlike device made mostly of wood, it worked very much like today's toy typewriters. You turned a wheel to select the desired letter, pressed down a bar to transfer ink impression to paper. The letters came out neat and clear, but handwriting was still faster. Still, it was a start and the ideas kept flowing. A Frenchman patented a "typographic" machine in 1833 that also worked. Only trouble was, the entire machine moved around the paper making it too clumsy for practical use. The Soviets got into the act about 1840 and built a typewriter looking much like a permanent-wave machine. An American in 1857, developed one with 78 type bars arranged in 13 rows. It was as tall as a piano and rather looked like one.

Development of the first practical typewriter began in 1866. Christopher L Sholes, a distinguished newspaperman, politician and printer belonged to an informal club of "tinkerers." They met to exchange gossip but between talk they worked to perfect unlikely gadgets. Sholes' project was an automatic page-numbering device. Discussing some of the ideas that were beginning to arouse considerable interest, one of the club members suggested to Sholes that he convert his numbering device to a writing machine. Sholes decided to try.

His main idea: place the type on a short bar and make it strike up

Lillian Sholes at her father's typewriter.

against a piece of paper held in place by a glass plate. It worked. During a demonstration the following week, he managed to print the letter "W" each time he struck a key. It was just a matter of time before he added the rest of the alphabet and numbers. As one reporter of the time wrote: "They let the funny thing go,/And by jingo!/ It prints the lingo . . ." Sholes and his backer, James Densmore took the machine to E. Remington & Sons, Mohawk Valley, N. Y., gunsmiths and sewing machine manufacturers. A company was established to produce and market the first practical commercial typewriter, the Remington No. 1, made in September 1873. In the decade following, a multitude of improvements changed the typewriter from a gadget to a machine vital to the persuit of business. On page 48, a further improvement is described; the carriage remains stationary while the type does the moving. A modern edition of Burt's "Typographer".

The race around the world

At just about this time every year, the major automobile companies unveil their new model cars in showrooms across the country, (see article, page 65). Usually tied to the new car presentations is a series of elaborate promotional schemes. Few schemes, however, can match the enthusiasm generated in 1903, when the Paris newspaper *Le Matin* and *The New York Times* teamed up to demonstrate the possibilities of the automobile and, at the same time, promote international good will. The papers offered a prize to the fastest car traveling a 20,000-mile route from New York to Paris via San Francisco. Vladivostok, Moscow and Berlin. Six cars representing France, Germany, Italy and America were lined up at the starting line, Times Square, while a quarter of a million people cheered them on.

The first casualty, a French Sizaire-Naudein, driven by Auguste Pons (father of Lily), occurred outside Poughkeepsie, N. Y. Pons was leading the pack when a rear axle snapped. Replacement parts were not available, and he was out of the race. Germany was represented by a Protos made in the Krupp works; France by a De Dion; Italy, a Zust. The American entry was a 60 hp chain-driven Thomas Flyer driven by Montague H. Roberts, driving teacher to the Roosevelts.

The trip across the United States was complicated by bad weather. Snow and ice hampered the cars in the East; drifts in Indiana slowed the Thomas to 8 miles in 22 hours.

In many parts of the country, entire villages turned out to see the cars pass; schools were closed and a holiday declared. Going through Wyoming, the Italian Zust was pursued by timber wolves, and the racers earned $200 in bounties by shooting animals.

On March 24, 41 days from Times Square, the Thomas rolled into San Francisco. The car then drove to Seattle where it waited for the Protos and was shipped to Vladivostok. On May 22, the Thomas and the Protos landed and headed west toward Paris leaving the Zust and the De Dion far behind. At many places, the cars were the

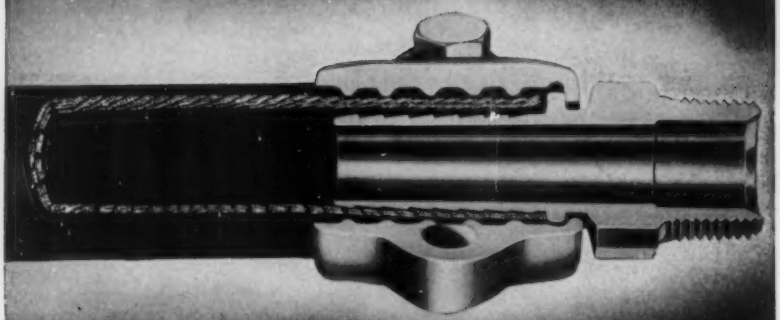
Long Island Automotive Museum

Several miles west of Vladivostok, Thomas and Soviet carts.

first ever seen. Roads usually looked like "a streak of mud as far as the eye could reach." At one point they found it easier bumping along the tracks of the Trans-Siberian railway.

On the evening of July 30, the Thomas drove into Paris. Although the Protos beat the American entry to Paris by four days, the Thomas was declared the winner because of the time it picked up crossing the United States. In 88 days of driving the Thomas covered 13,341 miles — a chore noteworthy even by today's standards. —*Benedict A Leerburger Jr*

ANCHOR® ...THE PLEDGE OF PERFORMANCE



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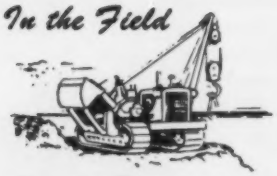

On the Road

In the Shop

Engineers and operators rely on these easily applied, streamlined Anchor Clamp-Type Couplings for fast, emergency repair and field service, as well as original equipment application.

Designed to accommodate normal variations in hose, they can be applied in the field with no tools other than a pair of automotive-type wrenches, and once applied, provide a sure, safe, leakproof connection that will remain intact up to the burst point of 2 and 3-wire braid hose.

Anchor Clamp-Type Reusable Couplings are supplied in high, medium or low pressure styles, for 3-Wire, 2 Heavy Wire, 2-Wire, 1-Wire, and Hi-Burst 2-Rayon Braid Hose, as well as Spiral Wire Suction Hose.

Write for Catalog No. 304.

Andy Anchor says:

"The Anchor representative who calls on you is a qualified specialist with years of experience in the hydraulic field. He will welcome an opportunity to help you with your hydraulic plumbing problems.

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READER TO EDITOR

Why not a rubber car?

To the Editor:

Cars of today use metal as if there weren't an alternative in sight. Yet rubber should be familiar to makers of cars. Rubber padding all around the sides of cars, also covering bumpers and protecting the lights, would do much to make driving more fun, more relaxing and less costly. Head-on collisions would still be fatal but sideswiping would be dismissed with "so sorry." Expense? To a degree it would be more costly to have steel covered with rubber. Yet there would also be a saving since the metal underneath the rubber padding would be left raw. Maintenance? Whoever spent hours polishing a car knows it is not too easy. Rubber can be cleaned chemically—needs no polishing. Let us grow up and grow into the car of the future—the new soft car.

—Bruno Linsker
New York City

Competent supervisor

To the Editor:

Read your editorial, "Old Man Noah," Aug 21, p 31. Noah did alright with his project but with his boss being "Engineer of the Universe," he had an Almighty competent supervisor to guide him. —R D Martin
Buffalo, NY

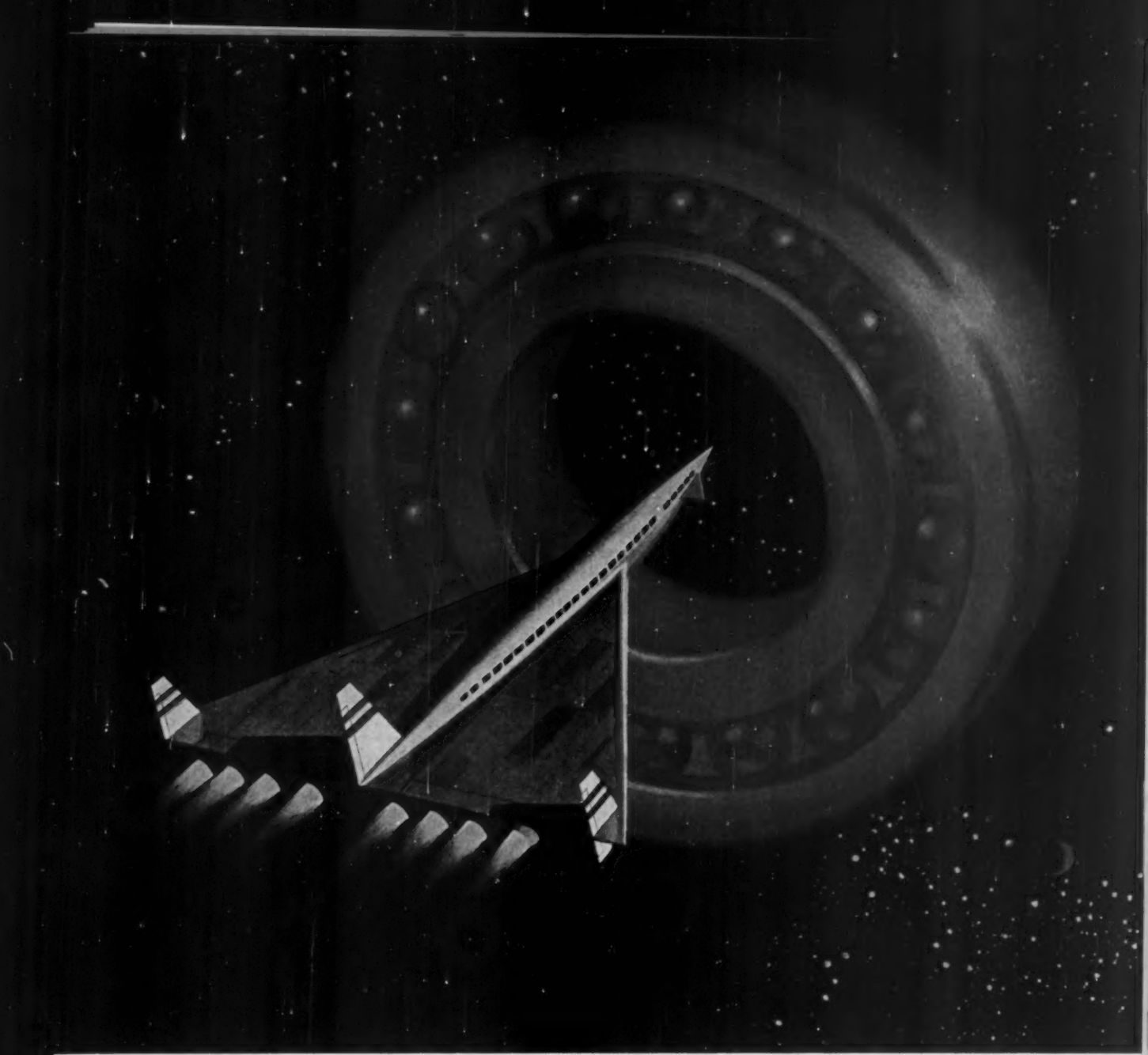
Freedom isn't simple

To the Editor:

I was disappointed with your June 26 editorial on "Leader, Not Dictator," p 39. There is no argument for dictators as such and certainly this is not my disagreement, but when you say Trujillo is dead, long live freedom, I am sure that you missed the point of the impact of Trujillo's death. In the first place freedom isn't nearly as simple as that. In the case of Trujillo we probably face the current alternative between supporting a "rightist" dictator as compared to a "leftist" dictator with the word "leftist" merely being a camouflage for one of the faces of Communism.

A point I would also like to make is that freedom is not as simple as you suggest. As you look at history you will find that individual freedom has never occurred outside a climate of Juda-Christian sense of morality and even here it does not exist to any great degree unless individual citizens understand and enthusiastically practice in the work-a-day world these religious

continued, page 14



BEARING WITH A RED HOT FUTURE

SKF MOTION ENGINEERING

Advanced ball and roller bearing technology

On special test equipment in SKF's research laboratory, experimental ball and roller bearings are run at temperatures up to 1000° F and above—conditions under which steel becomes red hot and loses its strength, while conventional lubricants burn or boil away. To meet these problems, bearings made of special heat-resisting alloys and exotic new materials are tested and evaluated. New ideas in design and new approaches to lubrication are constantly being investigated.

Bearings to resist extremely high temperatures are needed for improved, high performance jet engines, gas turbines and other equipment. Special SKF bearings have been tested successfully in environments at about 1000° F. Under certain conditions of operation, much higher temperatures are practical.

Research like this is your assurance that SKF will always keep pace with demands for the highest possible performance in all major types of rolling contact bearings —ball, cylindrical roller, spherical roller, tapered roller and precision miniature. SKF Industries Inc., Philadelphia 32, Pa.

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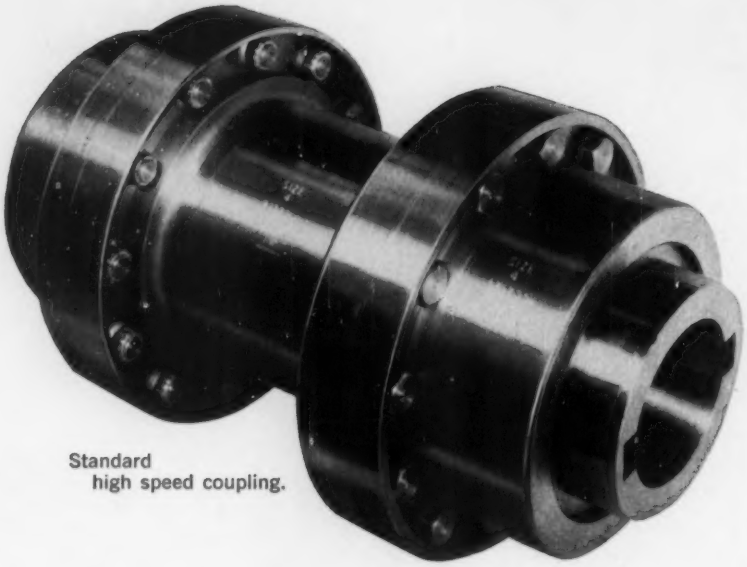

Standard
high speed coupling.

standard: 20,000 rpm
special: 70,000 rpm

Waldron high speed gear couplings are made with special care to prevent vibration—the usual troublemaker at high speeds. All parts are machined and inspected to close tolerances. Every assembled coupling is dynamically balanced on an arbor. Forged alloy steel gives them reliable strength, and they can be furnished grease-packed or continuously lubricated. Write for bulletin S-1500.

Standard size	HP/100 rpm	Max. rpm	Max. bore
1½ HS	19	20,000	1½
2 HS	24	18,000	2
2½ HS	50	15,000	2½
3 HS	87	12,500	3
3½ HS	125	11,000	3½
4 HS	210	9,500	4
4½ HS	305	8,500	4½
5 HS	410	7,500	5
5½ HS	550	6,500	5½
6 HS	675	6,000	6

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Makes it easy to pick the right

principles. These principles cannot be boxed and packaged and shipped from one part of the world to another; they cannot be transmitted genetically from one generation to another; they have to be understood and exercised in our daily actions. —J WM SYDNOR
Peoria, Ill

COMING EVENTS

OCTOBER

9-11 . . . . Institute of Radio Engineers and AIEE, National Electronics Conference, International Amphitheater, Chicago

9-13 . . . . Society of Automotive Engineers, National Aeronautic Meeting, The Ambassador, Los Angeles

15-20 . . . . American Institute of Electrical Engineers, Fall General Meeting, Statler-Hilton Hotel, Detroit

17-19 . . . . American Society of Lubrication Engineers, and ASME, 8th Annual Lubrication Conference, Morrison Hotel, Chicago

19-20 . . . . Illinois Institute of Technology and Armour Research Foundation, 1961 National Conference on Industrial Hydraulics, Sherman Hotel, Chicago

19-20 . . . . American Society for Quality Control, 16th Midwest Conference, Chase-Park Plaza Hotel, St. Louis

23-27 . . . . American Society for Metals, 43rd National Metal Congress, Cobo Hall, Detroit

24-26 . . . . Society of Automotive Engineers, National Transportation Meeting, Chase-Park Plaza, St. Louis

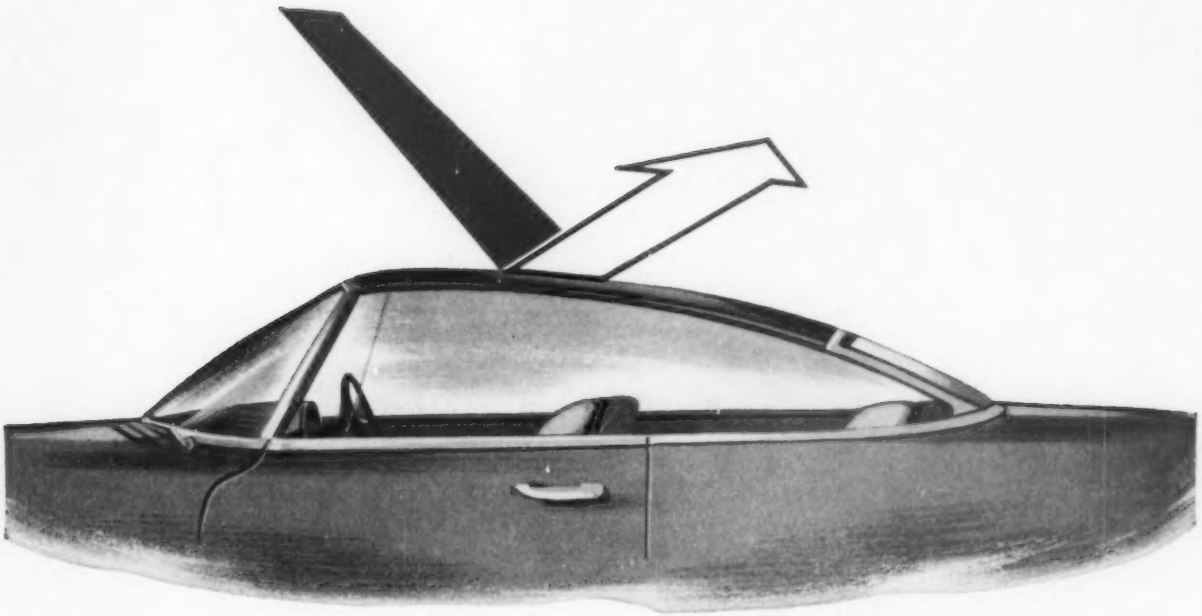
24-26 . . . . National Fluid Power Association, Fall Meeting, Sheraton Hotel, Philadelphia

25-26 . . . . Armour Research Foundation, 1961 Computer Applications Symposium, Morrison Hotel, Chicago

29-31 . . . . Society for Experimental Stress Analysis, ASME, NSF and others, International Symposium on Photoelasticity, Illinois Institute of Technology, Chicago

29-Nov 1 . . . . American Gear Manufacturers Assn., Semi-Annual Meeting, Edgewater Beach Hotel, Chicago

For a listing of addresses of societies and associations send 25¢ to Product Engineering Reader Service Dept, 330 W 42nd St, NY 36. Ask for brochure R 32.



Stop Heat Cold With Any Flexible Material—Aluminated

Your '63 car may be the coolest ever. Chances are there will be a new concept in temperature reflection under the roof . . . woven headliners combining aluminum's temperature reflectivity and light weight with fabrics' acoustical quality and good looks.

Automobile headliners—Aluminated—a new process by Thermo-Chem that impregnates any flexible material with aluminum. Alumination increases utility and widens useful temperature range by giving up to 20 times more heat (and cold) reflectivity.

Alumination doesn't crack, peel off, discolor. It won't lose its temperature-reflecting ability. And it adds strength without excess weight.

A thousand ordinary materials will soon be working in hot places they've never been before.

They can hardly wait.

Thermo-Chem Corp., 8 Noeland Ave., Penndel, Pa.

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more HAPPY BIRTHDAYS

for your products . . .

when you build in

R&M MOTOR PARTS!

Your products may encounter damp or dusty atmospheres. They may be bumped or dropped. Their motors may be overloaded and abused, the switches flicked on and off a hundred times a day. Yet customers expect instant, ample power every time . . . for years and years!

Robbins & Myers Series-Wound (Universal) and Induction Motor Parts can increase your products' life expectancy, whether you make portable tools for farm, home or industry; household appliances; business machines; or other power-driven items.

R&M engineers will select—or help *you* select—exactly the right size, shape and weight motor parts to fit your limitations. Parts are precision-built, using modern manufacturing techniques—an outstanding example is R&M's machine-wound armatures (details at right). Quality materials assure dependable, long-life performance under severe operating conditions and high speeds. And, R&M's high-volume production means low unit cost, to help keep the price of your products competitive.

Standard R&M Motor Parts are available in a large variety of mechanical details and electrical characteristics. Should performance requirements be unique, R&M also offers custom-designed parts. Write today for Bulletin 445A-PRE.

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FHP MOTOR PARTS

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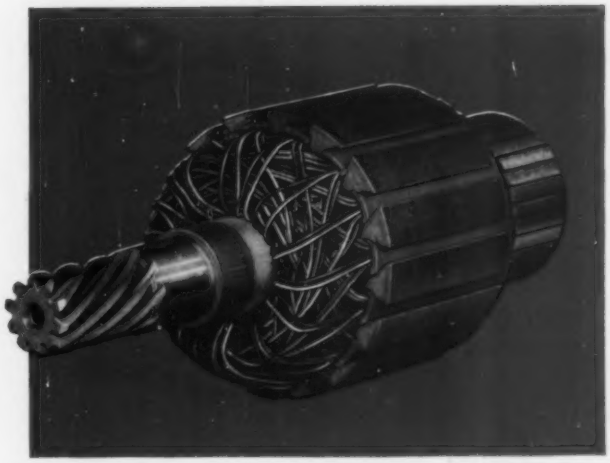
New R&M armature winding techniques provide longer, more dependable service. Coils are wound simultaneously and are exactly identical, assuring identical electrical and physical characteristics. Coils are uniformly positioned and anchored securely. Interlocked winding pattern resists conductor and coil end movement . . . minimizes abrasion of wire insulation, a common cause of high speed armature failure. Maximum coil end exposure permits greater heat dissipation, prolonging armature life. Uniform electrical characteristics reduce arcing at brushes, improving commutation and lengthening brush life.



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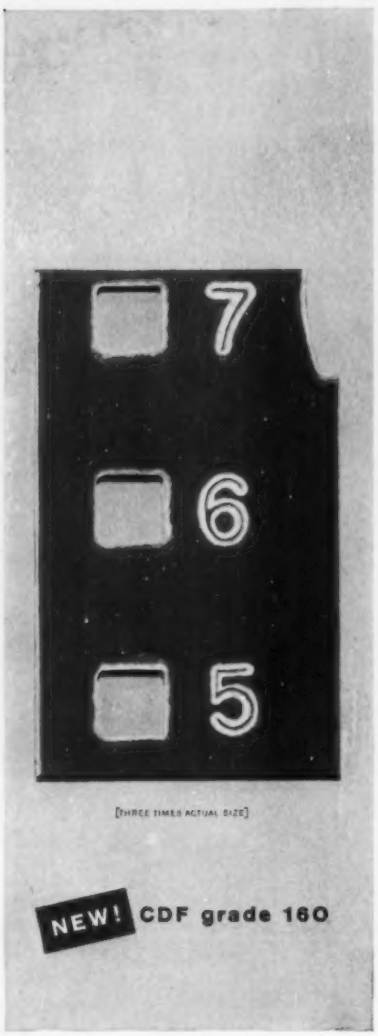

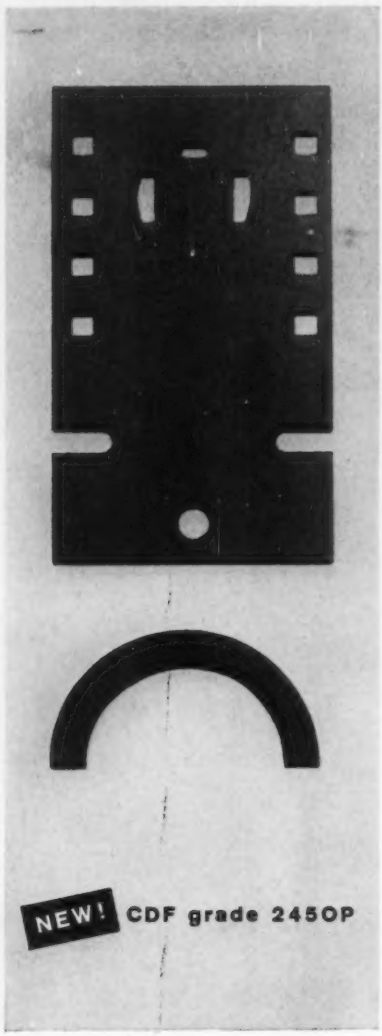

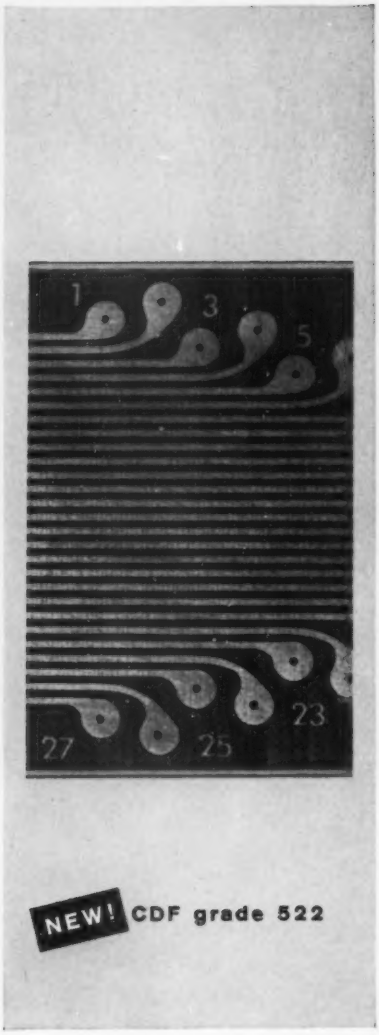

three outstanding new laminates!

High legibility letters, numbers or symbols can be stamped on this new warm punch, paper phenolic grade in the same die used for blanking and piercing! No separate operation is necessary . . . no registration problems. Markings are permanent and in sharp contrast. Ideal for capacitor caps, terminal boards, panels, spacers, coil ends, socket bases. Meets NEMA X and XP requirements.

Economical paper phenolic grade 2450P can be punched warm and has improved mechanical strength and lower moisture absorption properties. It is designed especially for mechanical and low voltage electrical insulation applications such as connector blocks, coil and bobbin ends, washers, plug and socket bases. Meets NEMA X and XP requirements.

Excellent wet electrical and other improved properties make this new copper-clad glass fabric Teflon* laminate ideal for radar insulation, missile antennas, critical computer applications. Circuits based on this grade will show minimum drift under varying temperature and humidity. Also available without copper for such uses as high frequency insulation in wave guides.

These are the newest materials of CDF research and engineering, developed to give you outstanding performance at minimum cost. Your inquiry is welcomed.

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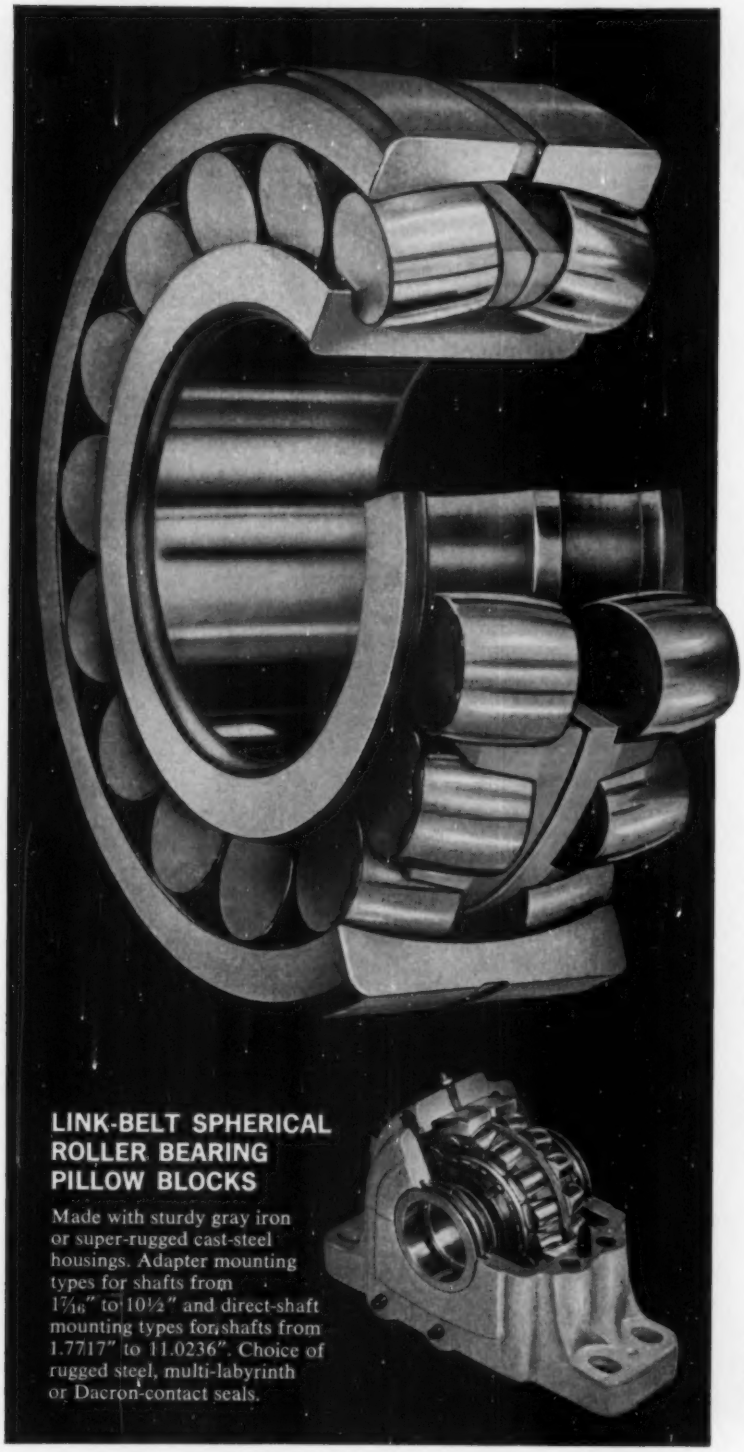
LINK-BELT SPHERICAL ROLLER BEARINGS:

measure these design values in terms of your applications



LINK-BELT SPHERICAL ROLLER BEARING PILLOW BLOCKS

Made with sturdy gray iron or super-rugged cast-steel housings. Adapter mounting types for shafts from $1\frac{7}{16}$" to $10\frac{1}{2}$" and direct-shaft mounting types for shafts from 1.7717" to 11.0236". Choice of rugged steel, multi-labyrinth or Dacron-contact seals.

GREATER CAPACITY!

The reason? *More rollers, larger rollers!* Bearing capacity depends primarily on effective roller Length, roller Diameter and Number of rollers (L x D x N). And Link-Belt offers the *largest effective roller complement* for all sizes of spherical roller bearings . . . rated according to accepted formulas of the Anti-Friction Bearing Manufacturers Association. This increase in LDN values provides extremely high capacity . . . and in users' evaluation, it adds up to far longer bearing life.

GREATER DURABILITY!

With balanced proportion design, Link-Belt spherical roller bearings possess durability characteristics that exceed the bearing industry's exacting requirements. Optimum balance of rollers, inner and outer rings must be obtained for increased bearing capacity . . . yet overall bearing dimensions must conform to an established international standard boundary plan.

Wrap-around, completely contoured retainers also contribute to durability through positive roller guidance and spacing. Precision-machined of centrifugally cast bronze, these husky retainers are far stronger than stampings or sand castings.

GREATER PRECISION!

Link-Belt spherical roller bearings are made in the world's most modern bearing plant . . . with the most-advanced tools and techniques known to industry. A rigid quality control program leaves *nothing* to chance. Each Link-Belt bearing is subjected to *758 actual inspections*. Microsmoothness and precision are continuously scrutinized by automatic machines. Result: these bearings have been specified by leading manufacturers of cranes, shovels, graders, vibrating screens, and steel mill, paper mill and foundry equipment . . . and for high-precision applications such as embossing rolls, printing presses and torque converters.

SEE BOOK 2760 for further precision, durability and high-capacity features. Contact your nearest Link-Belt office. Look under BEARINGS in the Yellow Pages of your phone book.

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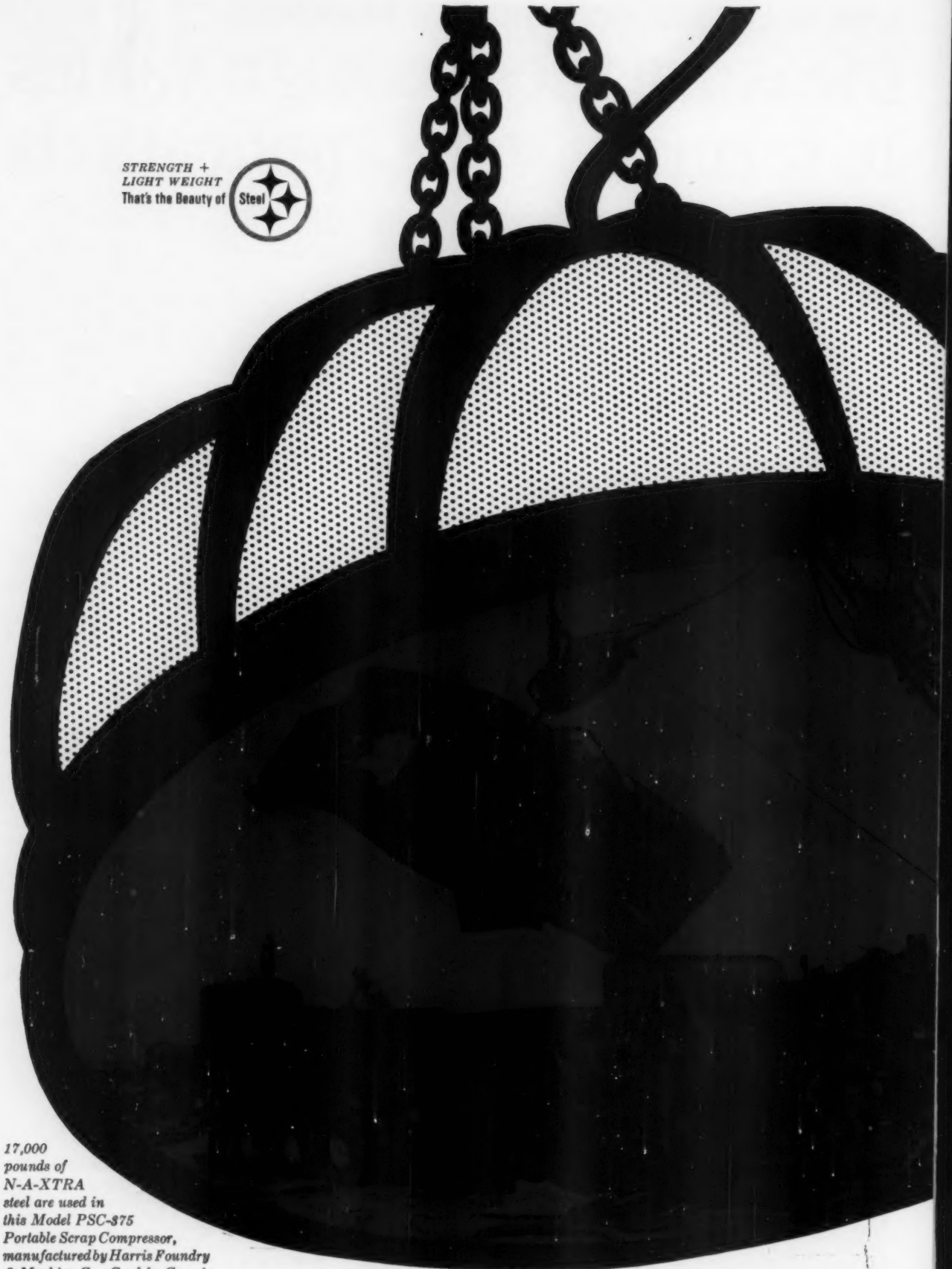
STRENGTH +
LIGHT WEIGHT
That's the Beauty of Steel



17,000 pounds of N-A-XTRA steel are used in this Model PSC-875 Portable Scrap Compressor, manufactured by Harris Foundry & Machine Co., Cordele, Georgia

STRENGTH + LIGHT WEIGHT OF

N-A-XTRA

HIGH-STRENGTH STEEL SOLVES PORTABLE SCRAP COMPRESSOR PROBLEM

This unique portable scrap compressor can squeeze an entire auto body into a 21″ x 36″ x 24″ bale of 20% dense steel scrap, using a ram pressure of 375 tons. Designed to be hauled from job to job by a conventional truck-tractor, it goes to work in outlying wrecking yards, compressing bulky scrap into marketable bales that can be shipped economically.

Because it must be moved over the highway and meet established load limits, a pressing problem in designing the PSC-375 was weight. Mild carbon steel with the required strength would weigh too much. N-A-XTRA high-strength steel solved the problem. It fully met all strength and fabrication requirements, yet kept total unit weight within acceptable limits for portability.

Portability may not be the controlling factor in your product—but the same steel that solved this problem is the one to remember when only the strongest steel will do. Pound for pound, N-A-XTRA steels are nearly three times stronger than mild carbon steel. Rugged conditions, heavy loads and weight-saving construction—in such applications, for example, as heavy machinery and pressure vessels—are challenges that N-A-XTRA is designed to meet.

With excellent weldability, formability, and toughness even at subnormal temperatures, N-A-XTRA low carbon, extra strength alloy steels give superior results with conventional fabricating methods, including cold forming, gas cutting, shearing and machining. N-A-XTRA high-strength steels are available in four levels of minimum yield strength, from 80,000 to 110,000 psi, and in sizes ranging from ⅛″ to 1″ thick, up to 72″ wide and up to 35′ long. For further information, write Product Development, Dept. PE-12, Great Lakes Steel Corp., Detroit 29, Michigan.

DESIGN NOTE: Model PSC-375, Portable Scrap Compressor, uses N-A-XTRA 100 (minimum yield strength, 100,000 psi) in engine and tank mounts, bed and side ribbing, arm housings and end housing. Sizes—¼″, ⅜″, ½″, ¾″ and 1″ thick. Fabrication followed standard gas cutting and welding procedures.

N-A-XTRA HIGH-STRENGTH STEELS

a product of

GREAT LAKES STEEL

Detroit 29, Michigan

N-A-XTRA STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

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CIRCLE 21 ON READER SERVICE CARD

BEARING BRIEFINGS

One in a series of technical reports by Bower

BEARING GEOMETRY MAKES OR BREAKS BEARING PERFORMANCE

To develop high capacity and optimum performance in a tapered roller bearing, it is essential that roller alignment be accurate. Correct roller alignment, in turn, depends on a critical geometric relationship between the cone back-face rib, and the cone raceway.

Perfection in this geometric relationship compels the rollers to align themselves perfectly with respect to the bearing geometry, and each roller shares equally in the work that is imposed. Figure 1 diagrams the important elements involved.

When this rib-to-raceway relationship is incorrect (because of either faulty bearing design or manufacturing inaccuracies), rollers experience misalignment and begin to skid and skew under load. As engineers know, poor performance and premature bearing failure are inevitable under these conditions.

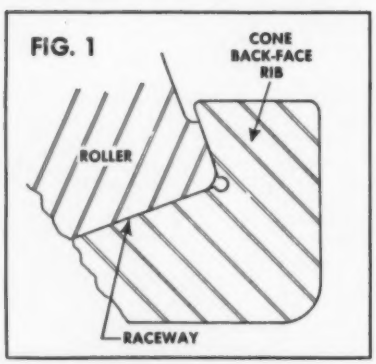


FIG. 1

In the design and manufacture of Bower tapered roller bearings, Bower engineers take great care to generate and hold an exact face angle on the cone back-face rib. In practice, this means that Bower bearings are designed for maximum life and optimum performance under any operating conditions. It means that Bower bearings retain accurate roller alignment under all speeds and loads up to the maximum for which the bearing is rated.

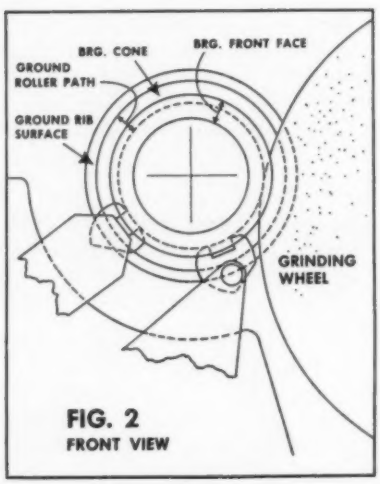


FIG. 2
FRONT VIEW

It's one thing to develop proper bearing design on paper, but quite another to carry it out consistently in manufacture. To this end, Bower engineers were instrumental in the design and development of a unique centerless grinder on which Bower precision grinds each bearing's cone raceway and rib-face simultaneously. The results obtained from these machines invariably meet or surpass Bower's exacting requirements and assure perfect roller alignment.

Figures 2 and 3 are front and top views which illustrate Bower's technique of centerless grinding rib-faces and cone raceways together. As a result, every component in a Bower bearing is perfectly concentric about its rolling axis.

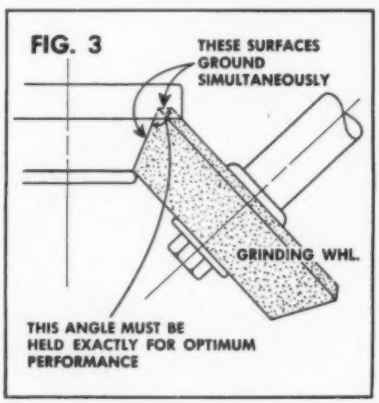


FIG. 3

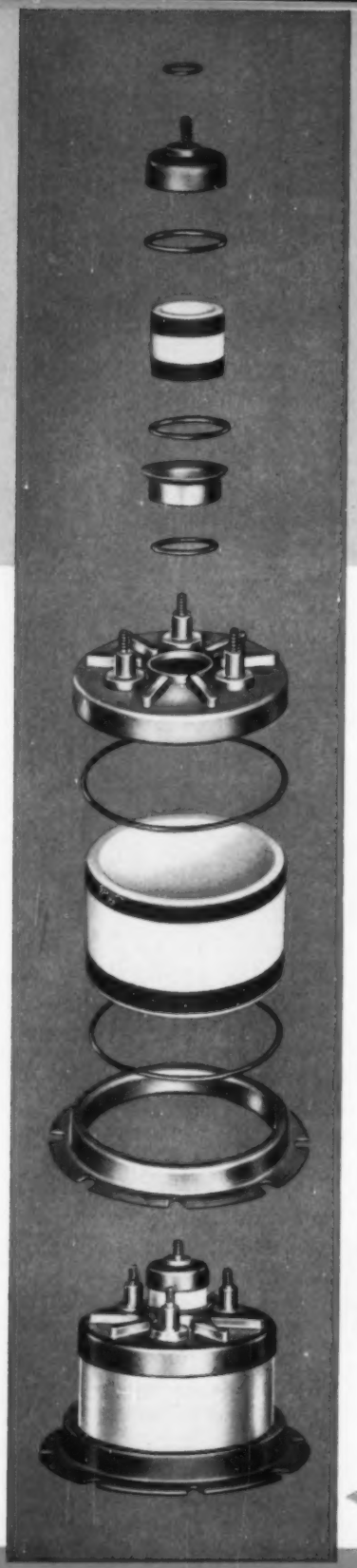
★ ★ ★ ★

When you require bearings, we suggest you consider the advantages of Bower bearings. Where product design calls for tapered or cylindrical roller bearings or journal roller assemblies, Bower can provide them in a full range of types and sizes. Bower engineers are always available, should you desire assistance or advice on bearing applications.

BOWER ROLLER BEARINGS

BOWER ROLLER BEARING DIVISION — FEDERAL-MOGUL-BOWER BEARINGS, INC., DETROIT 14, MICHIGAN

CIRCLE 23 ON READER SERVICE CARD→



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Bulletin 612 has 16 pages of metallizing details to help you find just the right combination for your application.

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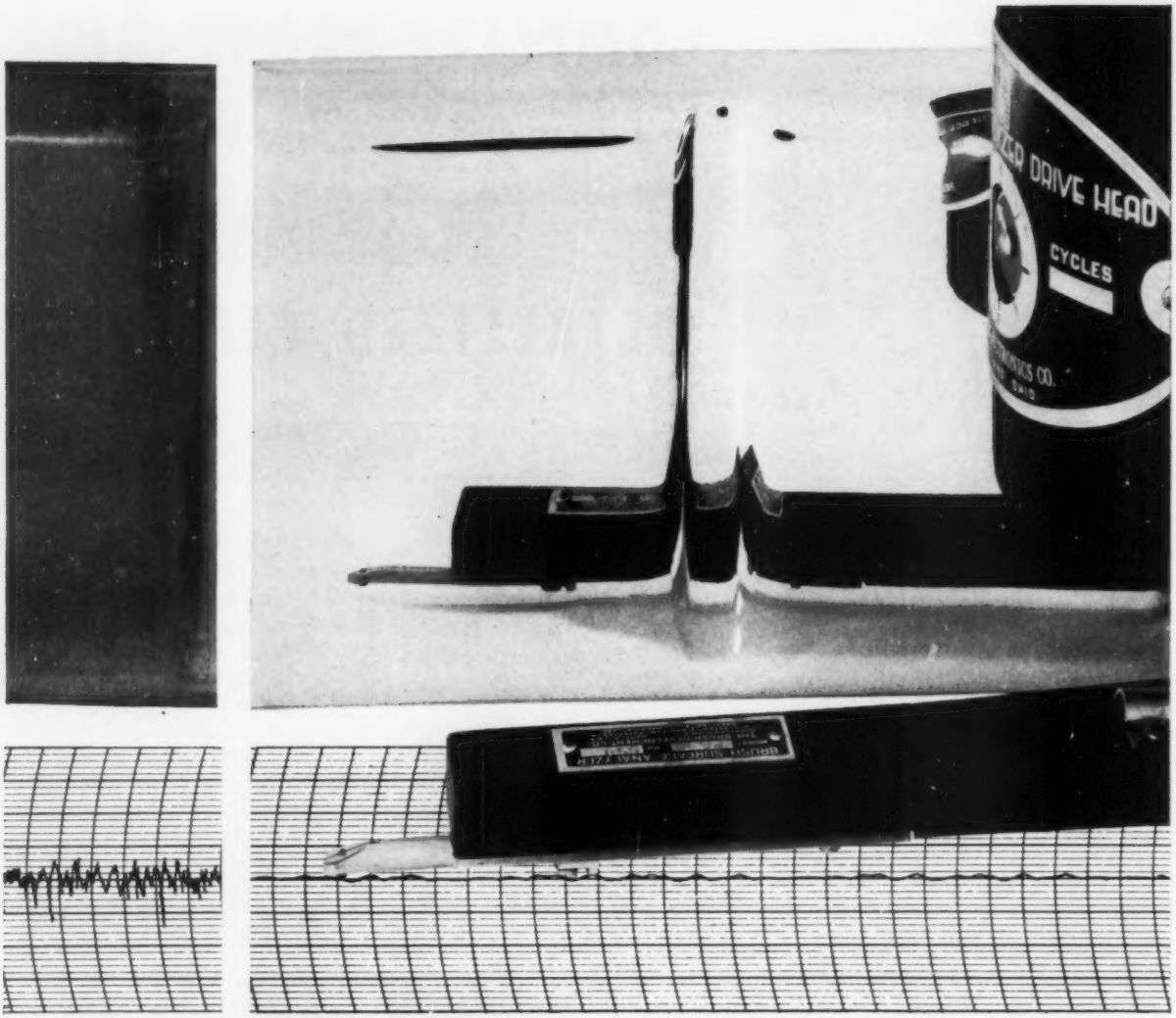

BEFORE: **Unplated steel section** shows surface variations averaging 40 micro-inches

AFTER: **Same steel section** plated with 2 mils of leveling Nickel and 0.01 mils of chrome shows an average variation from level reading of no more than 5 to 6 micro-inches

How leveling Nickel reduces costly finishing steps...saves production dollars

This steel section was plated with a layer of fully bright leveling Nickel. Rough surfaces were evened out—the need for polishing and buffing, before and after plating, was virtually eliminated.

Employed on a wide variety of basis metals—steel, zinc, brass, magnesium, copper—leveling Nickel coats and smoothes surface imperfections . . . reduces, in many cases eliminates, expensive polishing and buffing steps.

But economy isn't all you get with leveling Nickel. These Nickel baths . . . providing full brightness with leveling qualities . . . produce a brilliant mirror-smooth surface for that final blue-white flash of chrome. They offer remarkable resistance to nicks and scratches . . . protect basis metals against corrosion.

Other leveling Nickel baths, plated semi-bright rather than fully bright, are usually coated with bright Nickel before chrome plating. The resultant Double-Layer Nickel coating assures high brightness and lasting beauty . . . with increased corrosion protection.

Consider the advantages of versatile leveling Nickel baths for your products. For more information on Nickel plating, send for *The Contribution of Nickel and Chromium to the Durability of Decorative Plating.*

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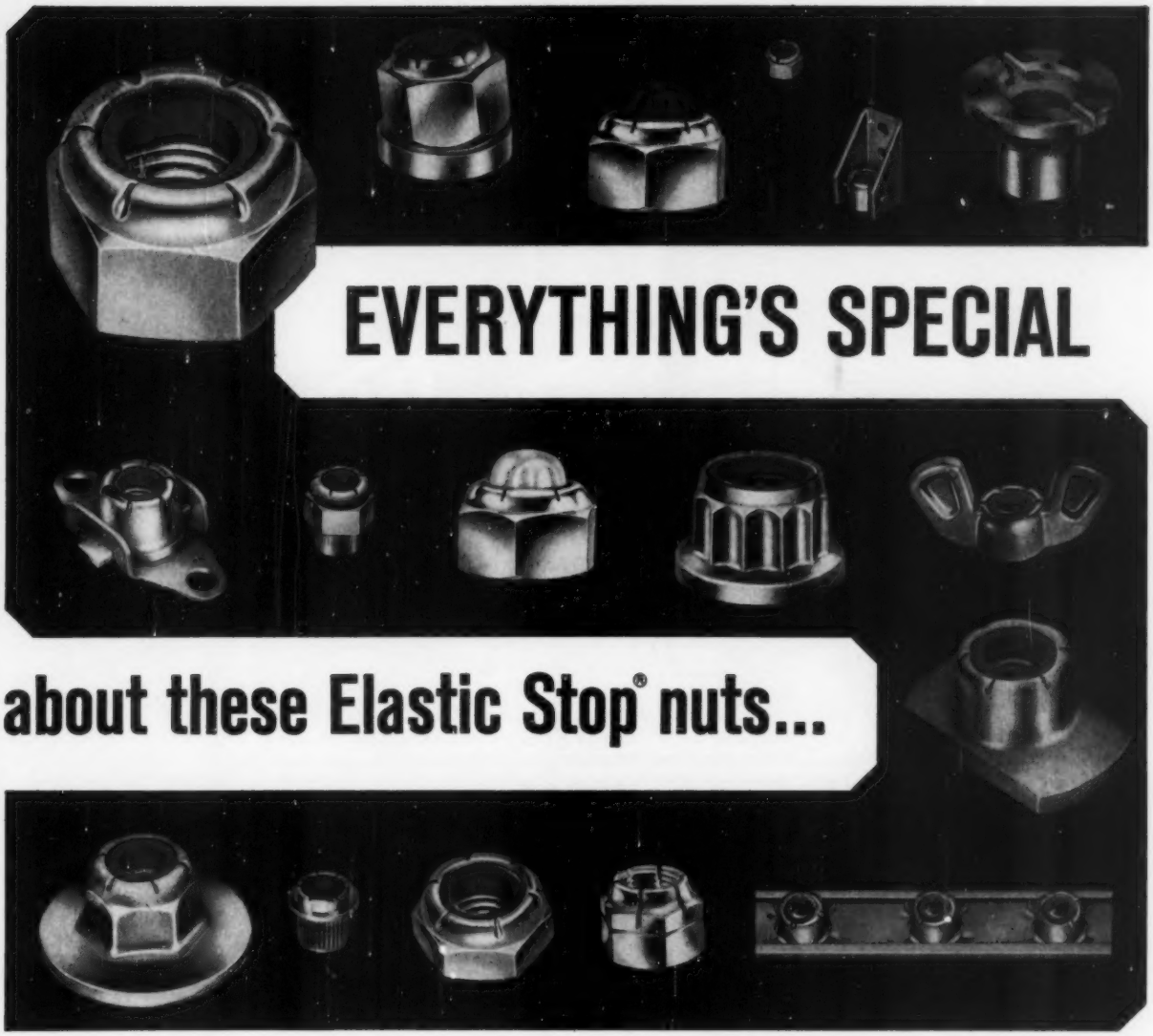

EVERYTHING'S SPECIAL

about these Elastic Stop® nuts...

...except their availability and ultimate cost to you.

Elastic Stop nuts come in hundreds of shapes and sizes. We have illustrated just a few to show you it is possible to choose a nut shape that will make your assembly job easier and faster.

How can you always be sure you have the real thing? Easy! The unique, instantly identifiable red nylon locking insert is your clue to an Elastic Stop nut's special brand of shakeproof, shockproof locking performance. Once you see "the ring of reliability" you know that *this* locknut is going to stay put . . . on any bolted connection . . . for as long as you want it to stay! It will not come off until it's wrenched off, and then it can be reused fifty or more times.

If your product's performance depends on tight bolted connections or precise adjustments, Elastic Stop nuts are the best, lowest priced, reliability insurance you can buy. And in figuring "true costs" the final figure should never be based on initial price alone. Value analysis has repeatedly demonstrated that product breakdowns or serious field service problems attributable to fastener failure easily cost more than the modest price of an Elastic Stop nut. The *ultimate cost* of stop nut quality and performance can make them today's "best buy."

ESNA's 30-year background in design and production of self-locking nuts assures you the most complete line in the business. For complete flexibility to meet your size, shape or volume requirements call on ESNA.

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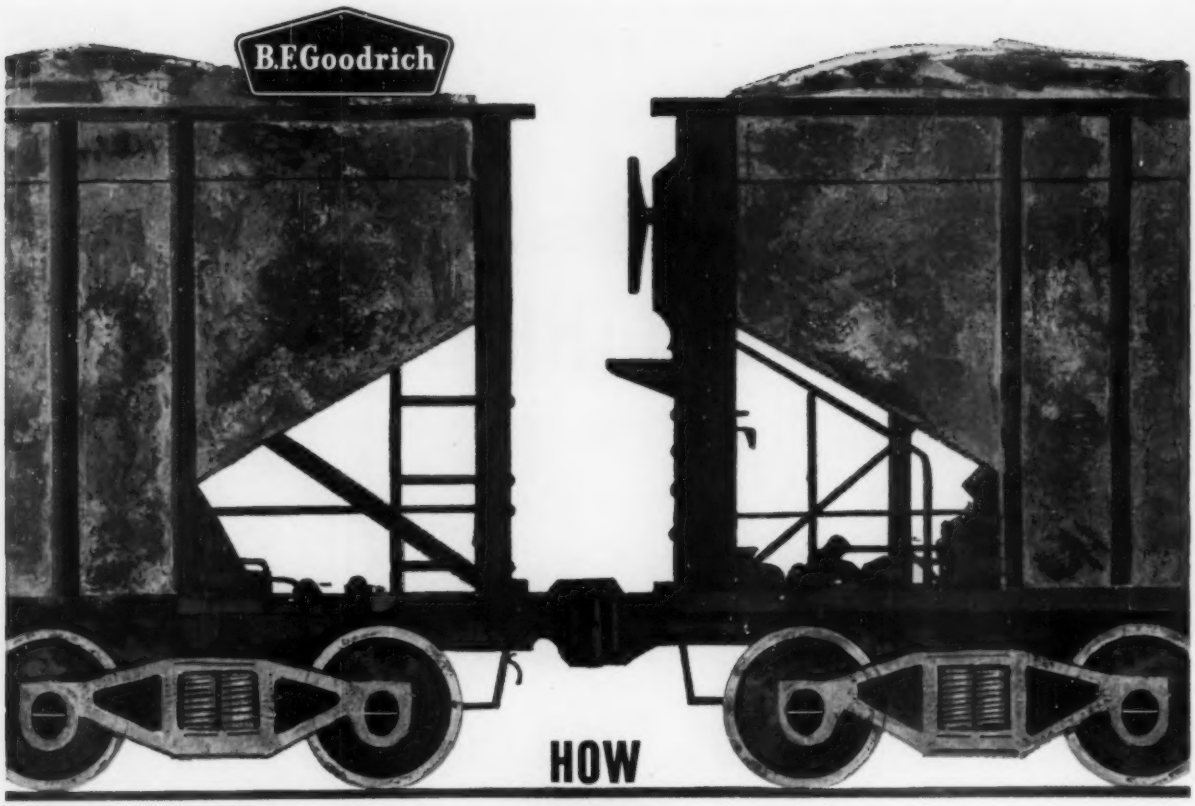
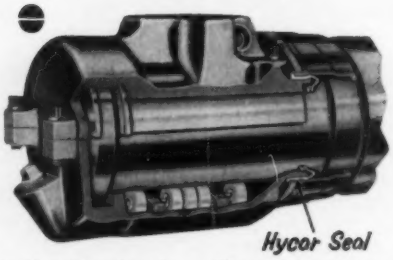
for the ring of reliability



HOW HYCAR PUTS A SEAL ON "HOT BOX" ELIMINATOR

Clevite sealed sleeve cartridges using an oil seal of Hycar are manufactured by Cleveland Graphite Bronze division of Clevite Corporation, Cleveland, Ohio. B.F.Goodrich Chemical Company supplies the Hycar nitrile rubber for molding into seals.



Hycar Seal

Inspection of the working parts of this sealed sleeve bearing cartridge is necessary just once every nine years, according to the manufacturer. Beyond this, the only maintenance needed to assure against freight car "hot boxes" is an annual check of oil levels. Fitted against the journal inside the housing is a positive oil seal made of Hycar nitrile rubber which permanently retains the lubricant.

The manufacturer says, "Without question, there isn't a seal that compares with this one." He's referring to the outstanding resistance to abrasion, to oils and other hydrocarbons and to heat offered by Hycar. Years of service under these tough conditions won't affect the resilience or effectiveness of these seals. The properties of Hycar solve a tough molding problem, too.

Here's another example of how Hycar improves present products, sometimes makes possible entirely new products for new markets. Can Hycar help solve your problem? Write for information—Department MJ-3, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company

a division of The B.F.Goodrich Company

Hycar Rubber and Latex

IF YOU DON'T USE 'EM . . . DON'T PAY FOR 'EM!

The **only** contacts you pay for in an AMPin-cert printed circuit edge connector are the ones you actually **use** for your specific circuitry, and here's why: AMPin-cert contacts are not fully pre-loaded into the housing. The unique AMP design, crimping wire directly to the contact, permits you to attach conductors to contacts **before** you load them. When you don't need two or three or six or seven of the available contact cavities, or a complete row of cavities in the case of one-sided boards, you don't load the contacts . . . and you don't pay for them!

So much for economics. What about contact versatility? The AMPin-cert line has five distinct types of contacts: Type I, AMP-leaf , a configuration which guarantees contact forces even on minimum-thickness boards. Type II, AMP-blade , a molded male tab housing to insure proper tab alignment, and a crimped type snap-in female receptacle offering three long, positive contact areas. Type III, DUO-Tyne , affords extremely high density, has four contact areas. Type IV, the right-angle AMP-flag DUO-Tyne , allows conductors to come out of connector at right angles, for easy cabling. Type V, AMP-taper in , ideal for quick jumpering, circuit change-over applications, accepts AMP taper pins.

Quality? AMPin-cert is quality, in the contacts and the housings:

- Contacts are phosphor bronze, gold over nickel plating
- Contacts accept single, multiple leads, and "snap-in" the housing without insertion tools
- Contacts are recessed in housing—no post insulation required
- AMPin-cert connectors will accept one-sided and two-sided boards

Ask us for the full AMPin-cert printed circuit connector story.

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GOODYEAR

EXCLUSIVE! GOODYEAR GREEN SEAL V-BELTS

to give you sets that are precision-matched in length to outperform...and outlast...all others

At no extra cost, GREEN SEAL *V-Belts also give you:*

Dimensional stability throughout the life of the belts via highly shrink- and stretch-resistant 3-T Process Cord or airplane-type steel cable.

Protection against dampness through special mildew-inhibited rubber compounds.

The most complete line of V-Belts in the industry—easily and quickly available through our nationwide network of distributors.

Still another "plus": The G.T.M.—Goodyear Technical Man—is available to help you select the right belts for any drive.

For your best buy in multiple drive belts—including new money- and space-saving HY-T Wedge V-Belts—look to Goodyear. Also, get the full story on P.D. (positive drive) Belts and Variable Speed Belts from your Goodyear Distributor. Or write Goodyear, Industrial Products Division, Akron 16, Ohio.

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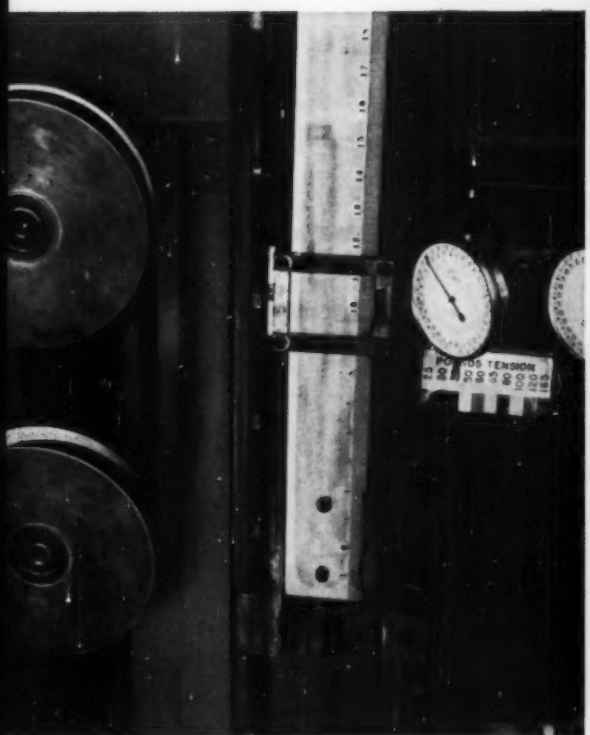
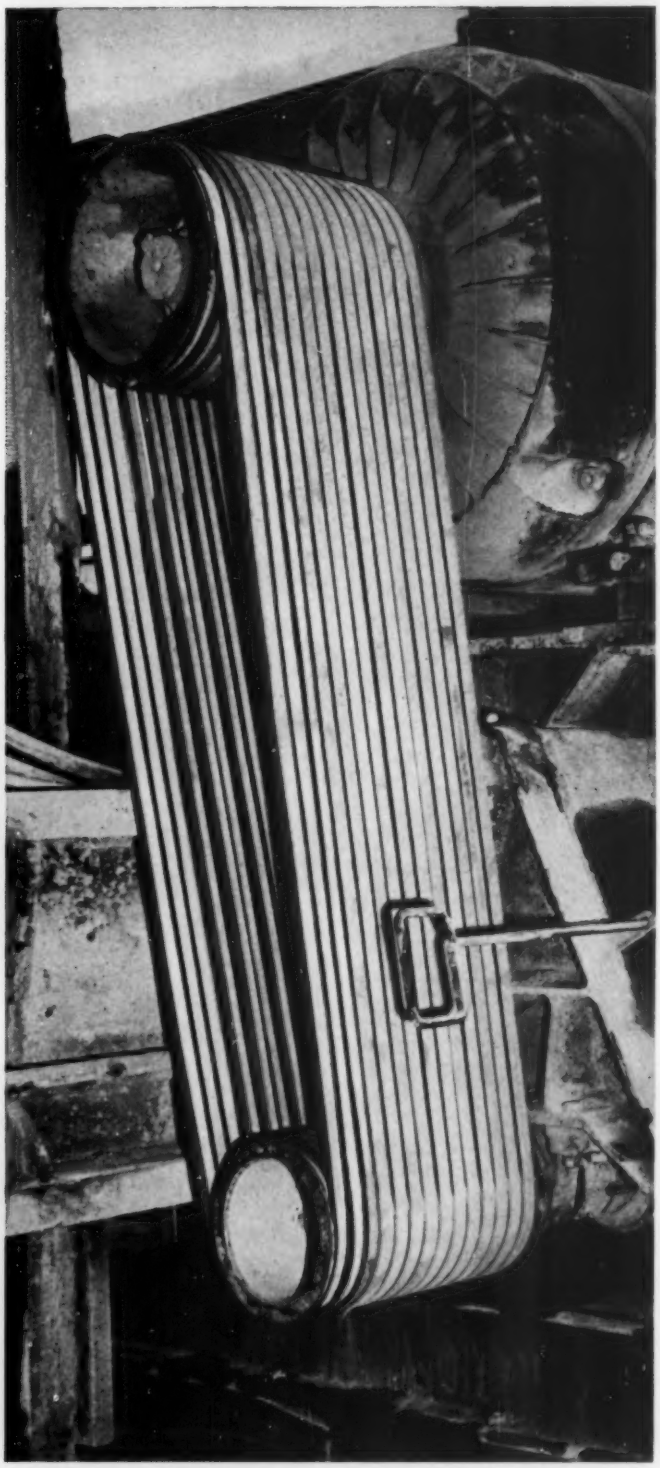
CODES TO 1/32"...



Length-coding GREEN SEAL V-Belts to 1/32"—not just 1/10" like most belts—takes this ultra-precision machine. *Only* Goodyear has this type of equipment, which is set by means of fine-tolerance steel templates to insure accuracy.

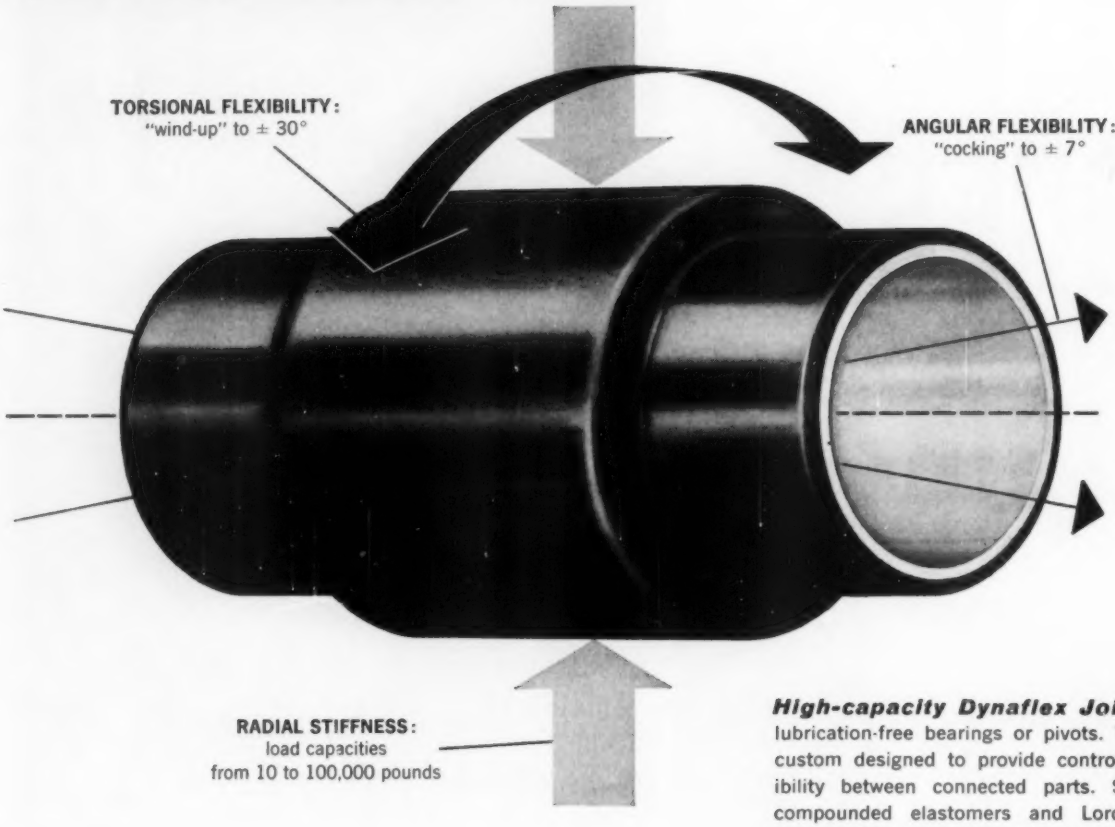


Harnessing this big, 22-saw stonecutter for 3 full years required COMPASS-V-Steel Belts by Goodyear. Over this period, the Goodyear belts helped carve up 20 tons of rock a day—over 15,000 tons in all. Normal V-belt life in this type of rugged service is a scant 6 months.

CIRCLE 29 ON READER SERVICE CARD

DESIGN FOR SUPERIOR PERFORMANCE

with Lord vibration/shock/noise control



High-capacity Dynaflex Joints are lubrication-free bearings or pivots. They are custom designed to provide controlled flexibility between connected parts. Specially-compounded elastomers and Lord-bonded construction assure longer life than metal units.

reduce installed cost, eliminate lube points

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Pivot points utilizing Dynaflex Joints offer real improvements in economy and performance.

These elastomeric pivots simplify assembly. Pressed directly into the as-cast recess or rough-machined socket, they insure positive radial positioning of parts. Exacting tolerances are not required; costly machining is eliminated. Grease fittings and periodic lubrication are outmoded; overall maintenance is greatly reduced.

Dynaflex Joints—used in torque and radius rod ends, load equalizer beams, spring eyes, machinery linkages, boom pivots—cushion shock, attenuate noise, reduce dynamic loading stress, assure accurate alignment.

Dynaflex Joints, with lower installed cost and longer service life than metal bushings, can be specially engineered for your application. Contact your nearest Lord Field Engineering Office listed here or the Home Office, Erie, Pa.

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DURAFLEX

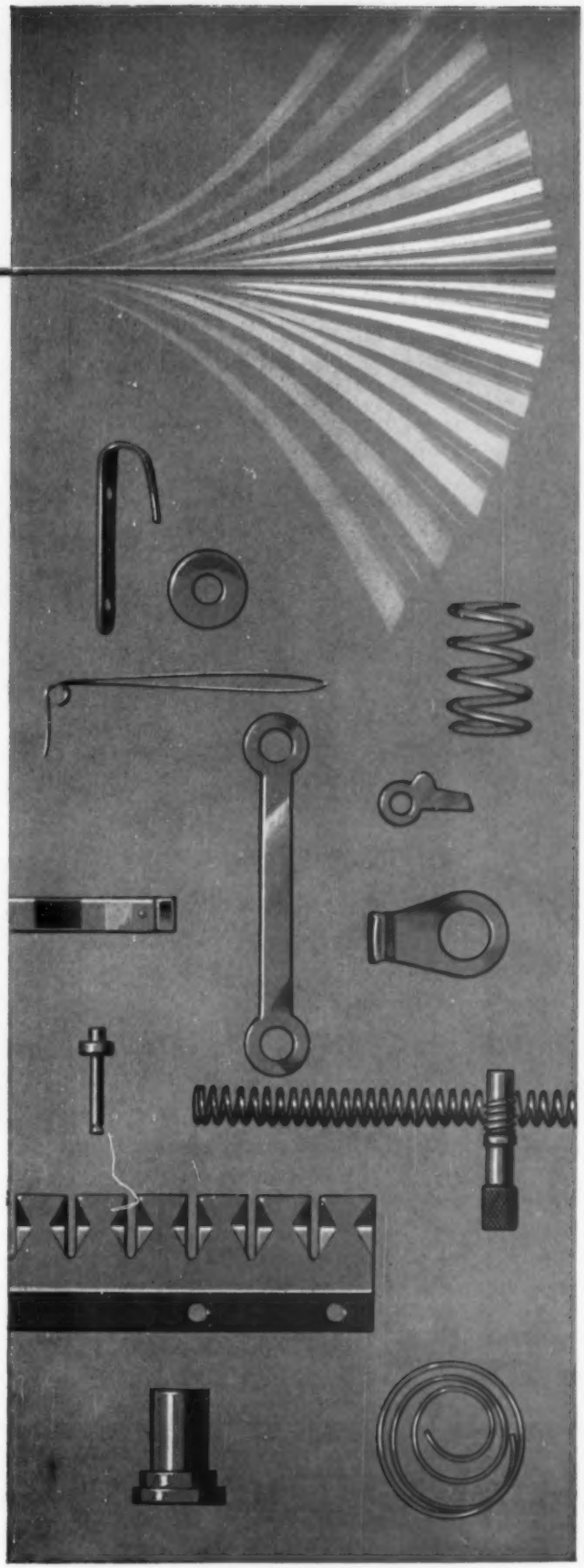
the more durable, ductile, flexible phosphor bronze— at no extra cost

Here is a versatile new type of phosphor bronze. The superfine-grain structure of Duraflex provides a considerable improvement in fatigue life over regular phosphor bronze. An independently supervised laboratory test recently proved this. Three springs of regular Phosphor Bronze, 5% (A) took a permanent set at about 200,000 deflections and fractured at an average of *453,374* deflections. Four springs of DURAFLEX Superfine-Grain Phosphor Bronze, 5% (A) showed no permanent set, no loss of load and no breakage at *4,000,000* deflections.

This new, higher quality Anaconda phosphor bronze is now available in several standard phosphor bronze alloys—in strip metal up to 0.062″ thick and up to 14″ wide in all standard tempers, and in wire up to 3/16″ diameter. Duraflex strip is also available in long rolls.

Within the capabilities of size and alloy composition, Duraflex strip and wire can be applied to the innumerable uses for which conventional phosphor bronzes are employed, and in most instances provide longer and more efficient service. *Yet Duraflex sells for the same price as regular phosphor bronze in the same alloys and forms.*

Publication B-38 tells the story. Write for your copy—or for any assistance from our Metallurgical Dept. in selecting the proper alloys for your design problems. Address: Anaconda American Brass Company, Waterbury 20, Conn. In Canada: Anaconda American Brass Ltd., New Toronto, Ontario. 61-1109



DURAFLEX®

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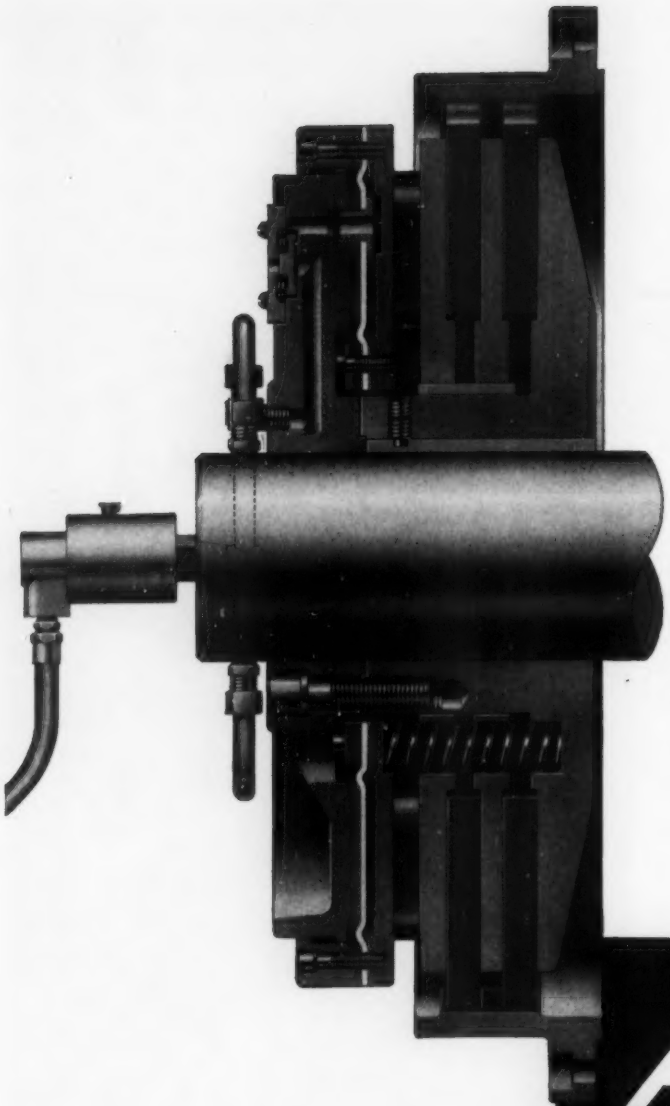

1. Quickest acting, most responsive air clutch available!
2. Finger tip control!
3. Built-in quick release valves! (Optional)
4. Requires minimum volume of air!
5. No adjustment necessary!
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8. Most compact!
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10. Available from stock in single and double plate types. Capacities from 8.5 to 460 hp at 100 rpm at 80 psi.

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of Mishawaka, Ind.

CALL THE TRANSMISSIONEER
—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery."

This air clutch, engineered to modern needs, provides maximum torque capacity in minimum space. Its operation requires less air, resulting in amazing sensitivity. It gives the operator split-second control—from "inching" to full engagement. Quick-release valves are built into the clutch itself, as optional equipment, for instant disengagement where such service is required.

The unique design of Air-Grip places the air seal disc at the end *farthest* from the pressure plates, which generate the heat inherent in clutch action. This combined with automatic internal ventilation, insures cooler operation and longer life under severest service. Call your local Dodge Distributor, or write for Bulletin.

DODGE MANUFACTURING CORPORATION
1200 Union Street, Mishawaka, Indiana

working with

Du Pont Zytel®

nylon resins

one of Du Pont's versatile engineering materials

Fuel regulator molded of ZYTEL® NYLON RESINS

is lower in cost, lighter in weight, easier to install

You might well ask, "lower", "lighter" and "easier" than *what?* The answer: *than automotive fuel-pressure regulators constructed of metal or glass and metal.* This new fuel regulator, which controls the pressure of gasoline injected into the carburetor, has three major parts precision-molded of Du Pont ZYTEL nylon resin . . . eliminating the expensive machining and finishing operations usually associated with metal regulators. Hence, cost is lower. Molded in ZYTEL, the regulator weighs only 2 oz., eliminating the need for metal clamps or other fittings. The new unit installs without adaptors to any gas line by inserting ends of the opened line into bushings pressed into the unit.

Key to the selection of ZYTEL for this exacting application is the combination of properties offered by these resins: high mechanical strength and resistance to gasoline and petroleum products at high engine temperatures.

The Miser-Mite fuel-pressure regulator is molded by Artag Plastics Corp., Chicago, Ill., for Milemaster, Inc., Exeland, Wisconsin.

On the next page you will find more examples of how the properties of ZYTEL nylon resins are being used to improve the design and performance of products in a variety of fields.

DU PONT

REG. U.S. PAT. OFF.

BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

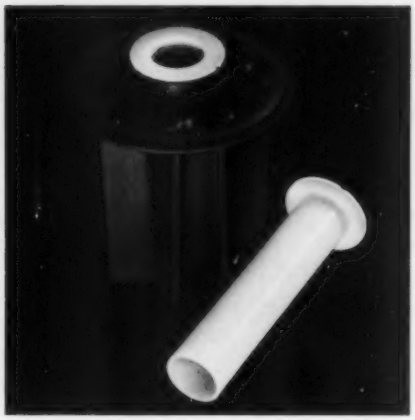
working with

Du Pont Zytel®

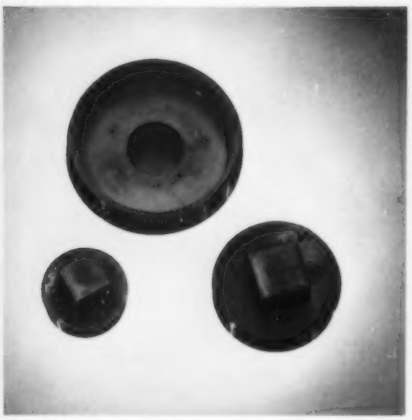
nylon resins

one of Du Pont's versatile engineering materials

Electric motor brush holder used in an improved electric impact wrench is a one-piece molded part of ZYTEL, providing excellent electrical insulation properties, wear resistance and high strength. Cost, including parts and assembly time, is 65% less than the three-piece fabricated brush holder assembly previously used. Molded by Amos-Burke Plastics, Inc., Syracuse, N. Y., for Chicago Pneumatic Tool Company, Utica, N. Y.



Swivel chair hub liner molded of ZYTEL® eliminates necessity of lubricating center spindles, maintains a wobble-free, tight fit through long periods of use. ZYTEL nylon resin was selected for its low coefficient of friction, resistance to impact and abrasion, and close molding tolerances. Molded by Nylon Products Corp., affiliated with F. J. Kirk Molding Co., Clinton, Mass., for Collier-Keyworth Company, Gardner, Mass.



Removable cleanout plug allows cleaning of sewage drainpipes. Molded of ZYTEL, the plug can be removed easily time after time, does not stick—because ZYTEL nylon resin resists the accumulation of mineral deposits from water. Quick, accurate injection molding eliminates need for sand casting and thread machining required by brass plugs. Coast Craft Industries, Glendale, California, for A. H. Voss Co., Los Angeles, California.

Three useful properties of ZYTEL® NYLON RESINS: high insulation... low friction... good moldability

Depending on the particular application, different combinations of properties offered by ZYTEL nylon resins become crucial—as witness the applications discussed on this page and the preceding page. To evaluate the design opportunities offered by ZYTEL for your application, consider the entire range of properties offered by ZYTEL nylon resins, and the many different formulations of ZYTEL available. The coupon below will bring you pertinent further information.

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...THROUGH CHEMISTRY

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ZYTEL® nylon resins

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DEVELOPMENTS TO WATCH

Power plants of all kinds—big, little, and bug-assisted are highlighting the news right now.

Chemists and electrical engineers are already working on bacteria-assisted batteries (*PE—Nov* 14 '60, *p* 8). Now metallurgists are taking a look at what the little bugs may do for them.

Says J. A. Sutton of the Bureau of Mines Research Center at College Park, Md: The prospect of **utilizing bacteria in mining and metallurgical processes** introduces a new and challenging area of investigation. Bacteria may prove important **in the selective separation of metals from ores** and metallurgical solutions, the **production of sulfur** from gypsum or pyrites, and the production of sulfuric acid from elemental sulfur.

It's time, he says, for the metallurgist and mining engineer to meet the bacteria that may prove helpful to them; and most particularly the *autotrophic* bacteria. These obtain energy by oxidizing inorganic compounds (sulfur, iron, nitrogen) and obtain carbon for cell structure from carbon dioxide. Some are photosynthetic; others chemosynthetic.

An information circular (8003), prepared by Sutton and biochemist J. D. Corrick, outlines the bacterial types that are potentially most useful, and a series of reports on experimental studies is to follow.

Another natural source of power—ocean waves—will go to work on the Island of Mauritius if plans of Britain's Hydraulics Research Station (Wallingford) work out. The idea, the *New Scientist* reports, is to impound the water and then use it to drive low-head turbines. Stored water would be fed by pumps between waves. Mauritius has a natural lagoon, almost closed by shallow reefs. This would be closed to form a reservoir and waves, breaking over the barrier, would be guided by a concrete ramp. Unusual feature of the system is that it is to be applied in an area where breakers and tides are relatively low—4 to 12 ft—as compared to the 30-ft height in Brittany and other areas where application of wave power is being considered. **First installation** is to have a **capacity of about 9 megawatts;** but this may be raised considerably.

The British have a new series of **four-stroke engines, weighing as little as 14 lb,** and designed for rotary grass cutters and other agricultural and industrial equipment. They are being introduced by Villiers Engineering Ltd, Wolverhampton, England.

First into production is a single-cylinder, blower-cooled, horizontal-shaft engine developing 0.92 bhp at 4000 rpm. Cylinder head, cylinder block, crankcase cover, fan and blower casing are light-alloy pressure die castings. Crankcase and cylinder block are cast as one unit and the cylinder head is detachable. The cylinder has a cast-iron liner, nickel-alloy valve seat inserts and separate valve guides. This is the 14-lb unit, and it's splash-lubricated, has a high-voltage flywheel magneto ignition and a recoil starter.

Coming up next are **75 cc and 150 cc** units, the larger weighing only 26 lb and developing 2 bhp at 220 rpm, 2.8 bhp at 3000 rpm and 3 bhp at 3500 rpm. Maximum torque is 5 lb/ft at 2500 rpm.

Fuel cells are another power source that's receiving plenty of attention. R. M. Lurie and Carl Berger of Ionics, Inc, say in a report prepared for this week's Electrochemical Society Meeting that hydrogen-halogen regenerative, membrane-type fuel cells should have a **service life of 1000 hr or more.** They're now testing a number of regeneration techniques—electrical charging, heat, radiation—and are also testing the effects of a number of variables (water content, capacity, thickness) on membrance performance.

Other new developments in fuel cells, slated for discussion at the same meeting: **Isotope-assisted systems** (using radio-isotope-activated electrodes to boost capacity);

high-temperature fuel cells of novel design which **may operate on wide range of fuel gases,** including carbon monoxide and petroleum hydrocarbons; and **cells using soluble lithium hydride electrodes** in a fused lithium chloride—potassium chloride electrolyte.

• • • •

On the materials front, there are new cushioning and filtration materials, and new developments in the high-temperature metals field.

Better filters for removing even very small concentrations of impurities, may stem from research on a new group of fiber- and film-forming polymers at DuPont.

Technically known as polymeric thiosemicarbazides, they are chelating agents which pick up objectionable metal ions selectively from solution. But, unlike most chelating agents, they are readily spun into fibers or cast into film so that fiber batt filters and other special filtration devices can be made. DuPont emphasizes that, as fibers, the new materials are no better than those made from other polymers. The advantage is that the new materials combine acceptable performance as fibers with outstanding performance as chelating agents.

Rubbery materials suitable **for impact cushions** on auto dashboards and other **vibration-damping** applications, and showing promise too, for use as solid rocket fuels, can be produced by the same irradiation techniques already used to improve many types of plastics. In this case, the irradiation not only helps to cure the material; but also can serve to bond the rubber to adjacent metal—the rocket fuel to its casing, for instance. The resin used is a mixture of a diene polymer or a polymer, and an organic polyhydrosulfide. A "filler" in the form of an inorganic salt, either oxidizing or not-oxidizing, is also used. Esso Research has filed a patent application in Britain (860,316).

Chromium alloys with **"greater creep strength and oxidation resistance at temperatures over 2000 F** than any at present known" may soon be available commercially.

Continuing its program of research on chromium and its alloys (*PE—Sep* 8 '58, *p* 8) Australia's Defense Standards and Aeronautical Research Labs have found at least one alloy that **will sustain a stress of 13,000 psi at 2000 F for periods of well over 100 hr,** with a minimum creep rate of 0.2×10^{-4} in./in./hr. Until now, the research has been largely academic. But, a just-concluded agreement with DuPont gives the US company full rights to "investigate the chromium alloying process and manufacture the metal if feasible."

Iridium, too, may be heading for new high-temperature structural applications. Admittedly, it's expensive. But recent tests indicate it may have special advantages.

At 1800 F, for instance, iridium's **tensile strength is very close to that of tungsten.** Tests at Britain's Cavendish Laboratory show iridium has a tensile strength at 1800 F of about 45,000 psi.

At 3600 F, iridium's strength is only about 5500 psi. Tungsten is a good deal stronger—just under 10,000 psi. But, as C. A. Brookes and B. Harris of Cavendish pointed out to the Fourth Plansee Seminar, iridium is still a lot stronger than molybdenum or columbium at that temperature, and at least as good as tantalum. Furthermore, they say, **iridium is superior** to all the other refractory metals **in resistance to contamination** in atmospheres containing carbon and oxygen.

Beryllium is also getting a lot of boosters. New companies are entering the field, and competition is bringing increased research and decreased prices. Both powder and rod have been cut 10 to 15% this year, and further reductions are likely. This doesn't mean beryllium is a cheap metal. Vacuum-cast ingot is still about $70/lb; and fabricated parts range from $150 to $175/lb. But much is being done to reduce this figure. There is hope, now, for an improved casting process

that will produce sounder ingots as well as far better sheet material, and heat treatment studies are under way, to boost mechanical properties closer to the theoretical maximum in elongation as well as strength.

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Thin films of refractory and semi-refractory metals, deposited by sputtering on to fused quartz substrates, show promise for electrical applications—specifically, **high-temperature resistors,** R. B. Belser and D. W. Robertson of Georgia Institute of Technology report. But protection from oxidation is needed to reach the 1000 F goal in air.

Titanium, zirconium, columbium and vanadium films all show negative temperature coefficients of resistance, when they have been deposited at room temperature and the thinner the film, the more negative the TCR values. The negative TCR is ascribed to the presence of nitrides and oxides of the metals in the films. When deposited on hot substrates at 750 F, TCR values were more positive.

Molybdenum, rhenium, and tungsten films, as deposited, showed relatively low TCR values, and the films had high stability. Annealing in vacuum to temperatures greater than 1100 F stabilized the films and shifted TCR values in a positive direction.

The **platinum metal films** generally had TCR values ¼ to ½ those of the bulk metal—too high to be of value as normal resistor units. But, Belser and Robertson say, they do **show promise as resistor thermometers,** and they are the only ones, with the exception of gold, which will **stand temperatures as high as 700 F unprotected** without serious damage. (Osmium had a lower TCR value, but showed signs of oxidation at temperatures as low as 400 F). Alloys of the platinum metals with refractory metals show promise.

Biggest need now is for coatings to protect the films against oxidation and permit their use at temperatures above 700 F range. A report on the first part of the work, sponsored by the Air Force, has been submitted for publication and distribution by ASTIA.

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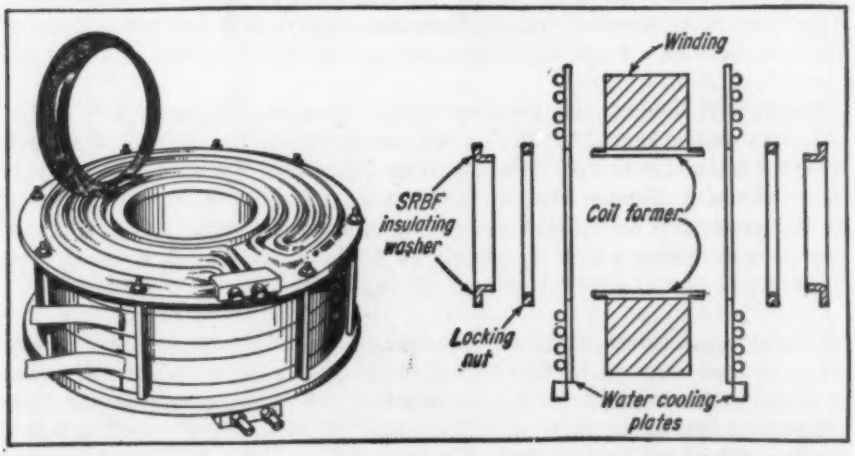
Of interest in the electrical field, too, are **aluminum foil coils.** S. A. Ahern of Mullard, Ltd says they make better magnets for laboratory use than the standard copper type. The reason: The packing factor is better, heat dissipation is easier, and winding is simplified. Copper foil might be better from the point of view of power losses, he admits. But it's difficult to obtain satisfactory copper foil and even more difficult to wind and bond it.

Ahern built the unit illustrated here, using coils wound by Venesta Foils, Ltd with 0.001-cm foil, coated with a 0.0003-cm layer of lacquer. Sketch at left shows an assembled coil. At right are the basic components. Ahern estimates that effective thermal conductivity is about 1/10 that of metallic aluminum.



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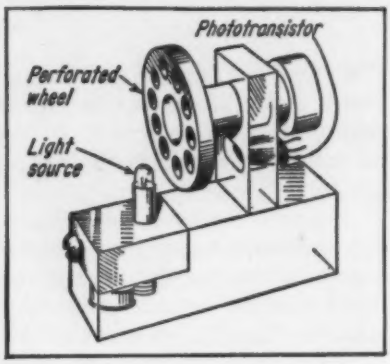
You can **build your own** laboratory **tachometer** with light source, a phototransistor, and a perforated wheel. Naval Ordnance Lab engineers tell how it's done:

The perforated wheel is attached to the rotating member. Then, as it rotates, light pulses passing through the holes hit the transistor and change its resistance, resulting in electrical impulses which can be counted to show rate of spin.

NOL says the system is **especially useful for low spin rates** (below 5 rps), where electromagnetic units may be unreliable.



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Need information on powder metallurgy? Ceramic colors? Research facilities? What those installment plans really cost? How to buy a tape recorder? Here are a few of the things you can get—some free, some at relatively low cost:

Powder metallurgy principles are reviewed, and their application to nuclear problems outlined in considerable detail in the latest publication in the International Atomic Energy Agency's Review Series. This one, by H. H. Hausner, is a 72-page booklet with a good deal of tabular material on uranium oxide, beryllium, boron compositions, and other cermets and fiber compacts important in nuclear reactor construction. Priced at $1, *Powder Metallurgy in Nuclear Reactor Construction* is available from International Publications, 801 Third Ave, New York 22.

A ceramic glaze color chart, wall-size, that shows—with actual full-color squares—exactly what effect glaze composition has on the color that may be obtained has been prepared by Ferro Corp. The color produced by a given stain may vary considerably, depending on the chemical composition of the glaze itself. A chrome-aluminum-zinc "yellow," for instance, may produce an orange in one glaze, a pink in another. The color squares in the chart show exactly what happens. Though the chart was designed specifically for the ceramic industry, Ferro's Color Div has offered to make it available free of charge to PE readers on letterhead request. Requests should be addressed to James E. Simpson, Color Div, Ferro Corp, Cleveland 5, Ohio.

Advice on how to buy tape recorders is contained in a booklet just released by National Better Business Bureau. It tells what tape speed to use for various purposes, what types of microphones you may have, and even provides a simple glossary of tape recorder terms. Single copies are free from NBB, 230 Park Ave, New York 17.

What does it really cost you to borrow money? How much do you save by paying off in 18 months instead of 30? To help the installment buyer find a quick and accurate answer, New York's Savings Bank Association has developed a simple slide calculator. The top scale is "Cash you get when you borrow" or "Price of article less down payment." The slide carries the monthly payment, and true interest rate is read through a window opening for 6, 9, 12, 18, 24, 30, or 36 months. New York's mutual savings banks are making copies available to depositors.

Research organizations in the nation's capital—what they do; the facilities they have, and how many people they have to do it—are listed in a 72-page publication prepared by Metropolitan Washington Board of Trade's new Science Bureau. The publication lists nearly 200 R&D firms, plus government and related agencies, gives personnel and facilities data. The price: $2. —ARG

14 simple rules for Cooling with blowers

Pictures are better than words when you are choosing a blower configuration for a cooling system. Here are proven tips for best design.

ADAM M WILCZENSKI, specialty blowers, Torrington Mfg Co.

EVERY POSSIBLE mistake in blower application has already been made—but you don't have to repeat them. These sketches and comments are based on years of trial and error covering most cooling situations for electronic packages and other heat-producing equipment.

Some are simple common sense—but the kind of sense often forgotten in the heat of design, or in the squeeze of limited space. Others are rules-of-thumb based on recognized theory but translated to practical simplicity. Here are the problems most commonly encountered, with the right and wrong solution.

EDITOR'S NOTE: Details important to selection of a blower type were discussed in these previous PE articles:

Equations Find The Right Impeller, Jan 9 '61, p 53—Special flow and pressure coefficients enable you to determine approximate fan type and size in a step-by-step procedure if you know desired air flow, static pressure and rpm. Covered are axial, mixed-flow and centrifugal fans.

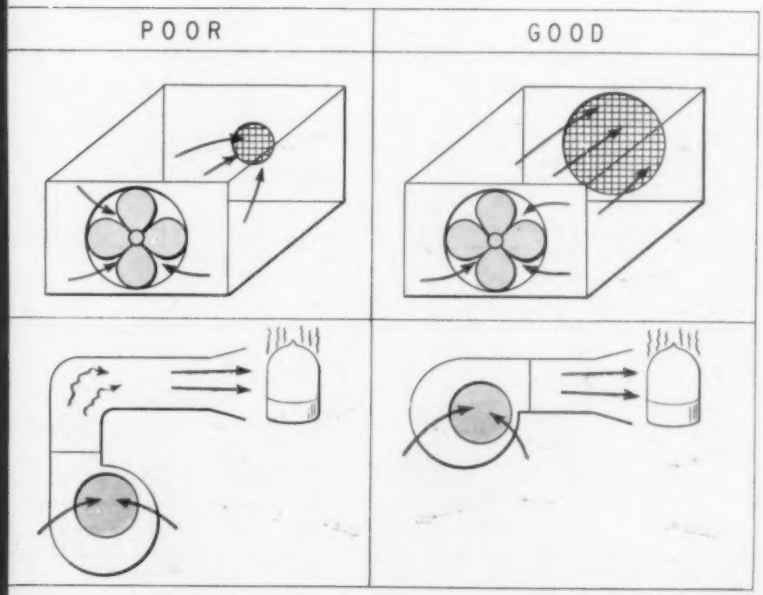
Mixed-flow Impellers Enter Air-moving Field, Jan 5 '59, p 56—Author tells how these impellers, introduced for air conditioners, outperform older types when pressures are too high for axial fans and too low for centrifugal blowers.

Guide to Fan Selection, April 28 '58 p 92—Discusses use of multi-rating tables for selecting motor size, regulating volume of air, reducing fan noise, and reviews basic fan laws.

How You Can Measure Airflow, June '57, p 145—Describes practical test setups for determining rate and pressure.

When Air Is The Coolant, Feb 16 '59, p 54. A quick way to estimate whether the assembly will run too hot. *—F D Yeaple*

Application Design



1 DISCHARGE GRILLE
Choose right size grille. A restricted discharge opening requires more air horsepower for a given volume of flow. Don't forget that effective area of a wire grille is the total area of the opening less the projected area of the wire.

2 FLOW PATH
Design for short, straight, smooth flow path from impeller to heat source if possible. The useful velocity energy of cooling air is reduced by turbulence in abrupt turns and by frictional losses along the walls of the duct.

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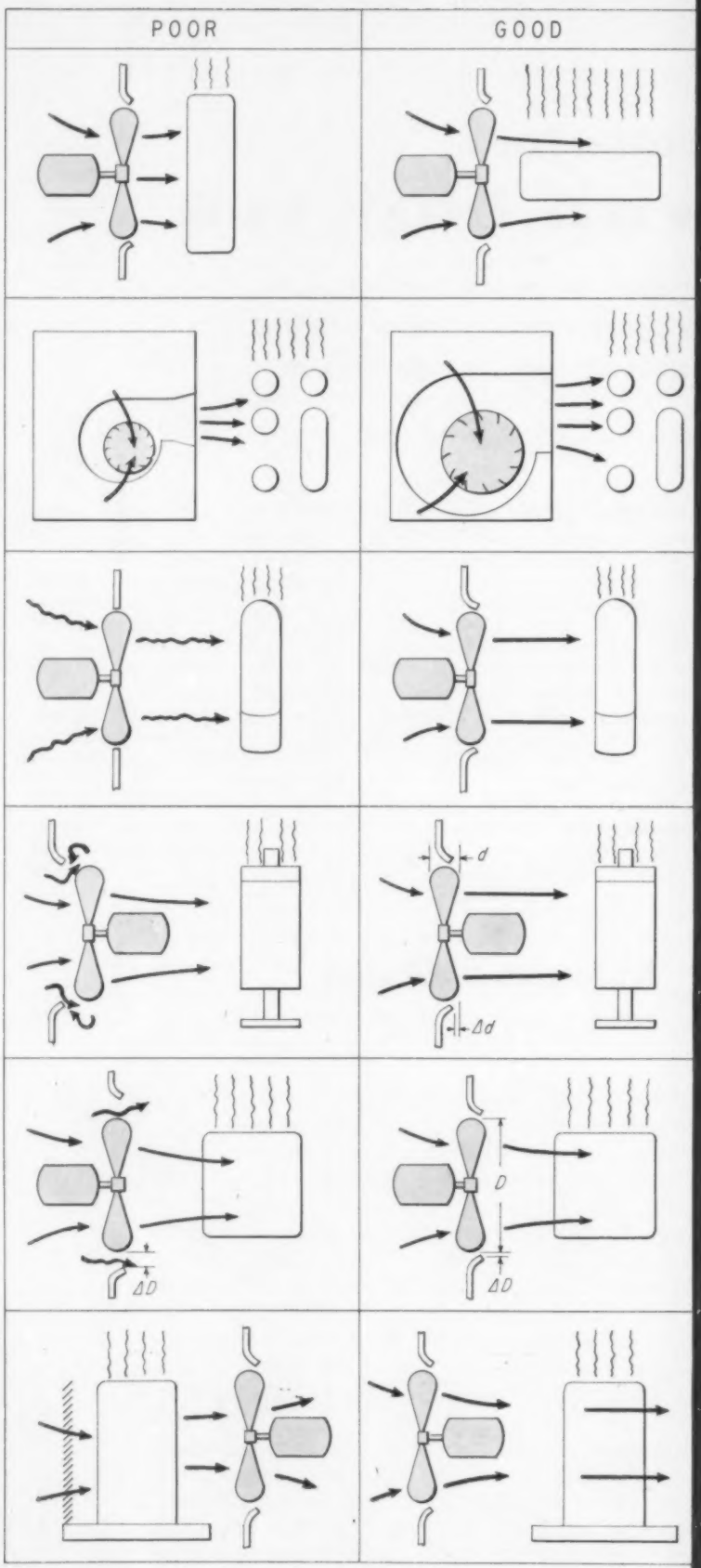


3 COOLING SURFACE
Arrange blower and heat source for maximum area exposed to air flow. This will increase cooling efficiency and help avoid hot spots. See previous article "When Air Is The Coolant" *(PE—Feb 16 '59, p 54)* for methods of estimating cooling.

4 BLOWER SIZE
Choose right size blower. Undersize blowers have higher air velocities inside casing for the same available cooling flow; they are noisier; and they require higher-power motors. Oversize blowers waste air or velocities are too low.

5 ORIFICE SHAPE
Choose a bell-mouth orifice for axial-type cooling blowers. Flow will be smoother and electrical power requirements less than for a straightedge orifice such as a hole cut in a cabinet wall. (Packaged units usually have bell-mouth orifices.)

6 IMPELLER POSITION
Locate impeller slightly downstream of plane of orifice (let $\triangle d = \frac{1}{3}d$). Never locate impeller all the way in front or back of the bell-mouth orifice, because flow-smoothing effect will be lost, and performance will suffer.

7 BLADE-TIP CLEARANCE
Nearly zero clearance is best, but if $\triangle D$ is 1.5 to 2% of D, performance is about as good (and costs are less). Larger tip clearances increase leakage losses and flow will be less (based on a given static-pressure head).

8 MOTOR LOCATION
Locate motor so that coolest air passes over it; motor will last longer and can be smaller. Also, less power is required by a fan if it is located in the coolest portion of the air circuit, and its diameter can be less.

9 HOUSING SHAPE
The housing should match the impeller. Either buy a packaged unit or have it custom-designed by specialists. Undersized housings choke flow; oversized housings waste space and fail to fully convert air velocity to useful pressure.

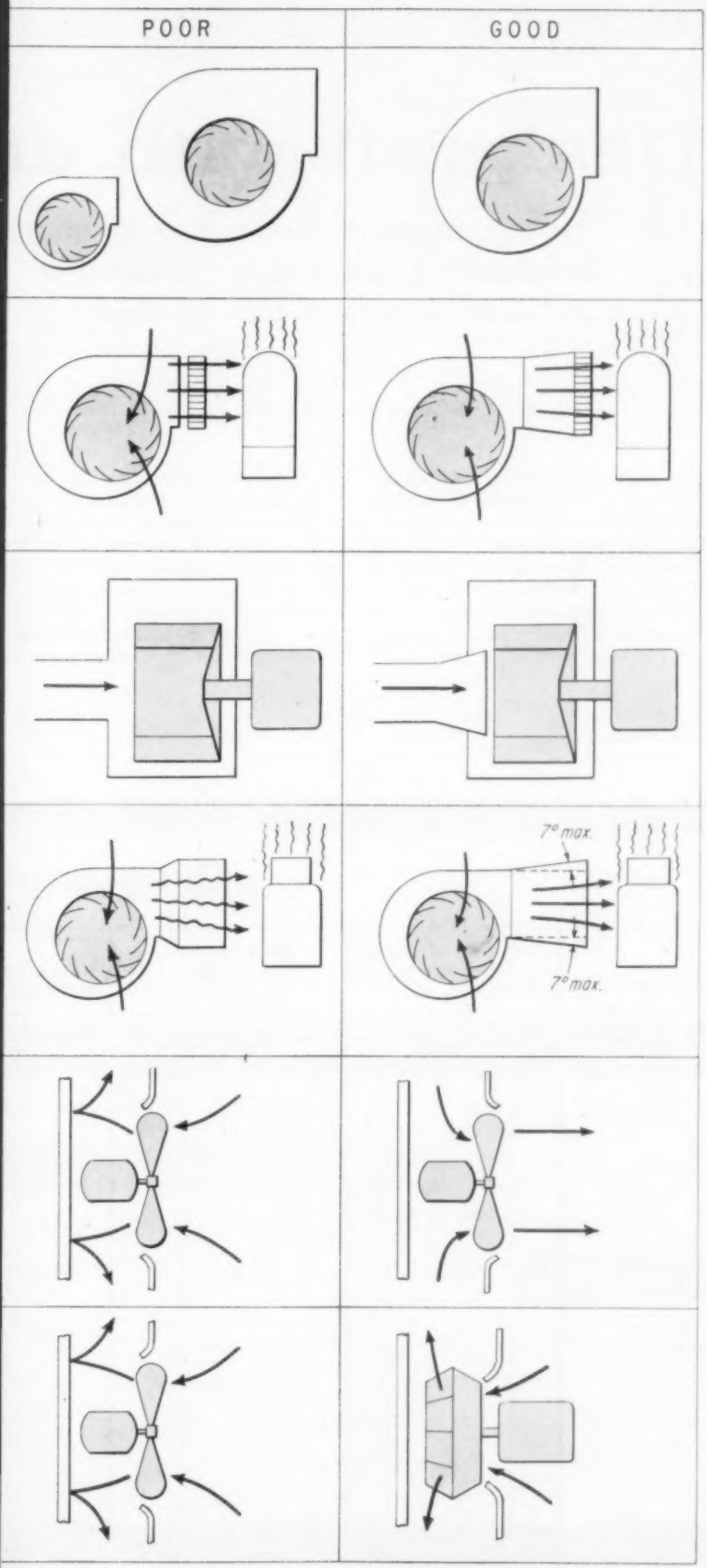
10 FILTER LOCATION
Locate filter at the blower outlet (not too close) and provide an expansion section or plenum to reduce air velocity. Excessive noise may be developed by high-velocity air in a filter mounted too close to the blower outlet.

11 BLOWER INLET
Inlets much smaller than impeller diameter cause turbulence and lower the efficiency. A good diffuser at the inlet of a radial blower will expand airflow area to nearly the ID of the blade ring (80 to 85% of OD for a blower with forward-curved wheel).

12 OUTLET DIFFUSER
Where blower air velocity is higher than needed, a diffuser at the outlet will gradually and efficiently expand the air and regain kinetic energy that would otherwise be wasted in turbulence. Don't exceed 14° included angle.

13 FLOW NEAR BARRIER
When moving air through ducts, shock losses will be high if air is blown against a nearby duct wall. There will be a gain in efficiency if it is possible to draw the air through and out of the duct in a smooth flow path.

14 IMPELLER TYPE
Direction of air flow might be better controlled if a different blower is selected. For example, if flow into a barrier cannot be reversed, a mixed-flow unit might work. Air discharge will then be more nearly along the duct axis.



Design it with diamonds

Don't underrate diamond as an engineering material. It offers many properties not available in metals or ceramics.

A G ASAFF, president, Diamond Tool Engineering Co, Boston

BESIDES BEING the hardest of all materials diamonds have other unique properties that make them ideal for applications needing:

- extreme dimensional accuracy
- dimensional stability
- high compressive strength
- resistance to mechanical shock
- low coefficient of friction
- corrosion resistance
- resistance to thermal shock

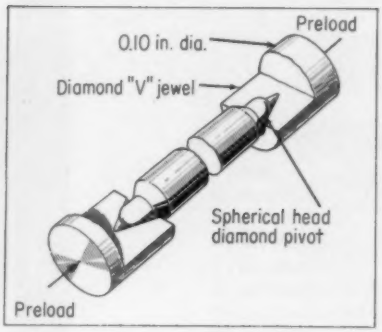
Although expensive and difficult to shape, diamonds are now a practical engineering material for miniature parts. Here, cost of material is small in comparison to cost of forming the part. And the ultraprecise dimensions that can be produced in diamonds alone may be vital for reliable operation of the assembly.

A diamond is a crystal of carbon with molecules packed closer together than those in any other material. This accounts for its rigidity, strength in compression and ability to take a fine surface finish.

Mechanical properties vary some-

Properties of diamonds

Melting point, F		Breaking strength in compression, psi x 10^6		Modulus of elasticity, psi x 10^6		Knoop indentation hardness, kg/sq mm		Relative wear resistance	
diamond	6990	diamond	11.2	diamond	105 to 150	diamond	about 6000	diamond	90,000
tungsten	5780	sapphire (synthetic)	1.8	tungsten carbide	100	boron carbide	2230	corundum	1000
tungsten carbide	5030	tungsten carbide	0.5 to 0.8	iridium	76	silicon carbide	2050 to 2150	sintered carbide	900
zirconia (stabilized)	4710	sintered Al_2O_3	0.4	tungsten	50	corundum	1600 to 2000	high speed steel	350
sintered alumina	3700								



Miniature jewel bearings

High-speed bearing of diamond operates to 90,000 rpm without lubrication. Preloaded thrust causes spherical head to wear its own mating surface. Line contact between spherical pivot and cone provides low starting torque. Because of relatively simple shapes, cost about $10 to $15 in quantity, is competitive with miniature ball bearings. Using a sapphire V jewel reduces cost but increases wear rate. Slight bearing wear during run-in does not change alignment of the shaft.

what in different directions because diamonds are single crystals. (This contrasts with metals and other multi-crystal materials where properties are averaged in all directions.) Even then, properties of diamonds are impressive:

- Modulus of elasticity is over 100 million psi. In one crystal direction it is as high as 150 million psi.
- Breaking strength in compression is approximately 11 million psi.
- Toughness provides resistance to mechanical or inertial shock.
- Abrasion resistance is better than any other material.
- Wear resistance is more than 200 times that of the best grade of high-speed steel at optimum hardness.

Diamonds take a fine surface finish and can be ground to ultraprecise tolerances. A diamond metal-cutting blade made by DuPont is ground precisely to a thickness of 12 carbon atoms (about 0.1 microin.) Moreover, because diamond is stable this dimension stays put with no measurable change barring abrasive wear. And,

and competing materials

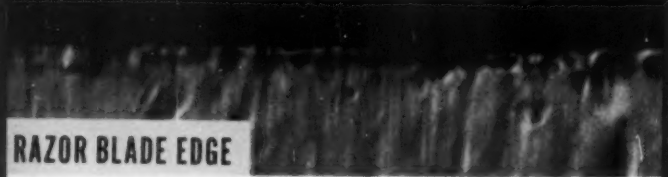
Thermal conductivity, btu/sq ft/hr/F/in.		Coefficient of thermal expansion, microin./in./F		Electrical resistivity, (ohm-cm)		Dielectric constant (air=1)	
silver	2900	quartz	0.28	sintered alumina	10^{15}	corundum	11.3
copper	2730	Invar	0.50	sintered beryllia	10^{14}	sintered alumina	8.9
aluminum	1540	diamond	0.80	diamond	10^{13}	sintered beryllia	7.0
sintered beryllia	1530	tungsten	2.4	electrical porcelain	10^{12}	hard glass	5 to 7
tungsten	1160	corundum	3.3	phenolic	10^{10} to 10^{11}	diamond	5.7
diamond	1020	sintered alumina	4.9			electrical porcelain	5 to 6
molybdenum	990						
nickel	640						

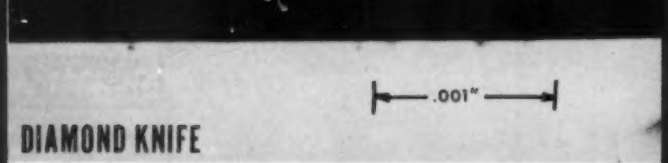
A revised scale for hardness

ORIGINAL MOH SCALE		NEW MOH SCALE	
1	talc	talc	1
2	gypsum	gypsum	2
3	calcite	calcite	3
4	fluorite	fluorite	4
5	apatite	apatite	5
6	orthoclase	orthoclase	6
7	quartz	vitrious silica	7
8	topaz	quartz	8
9	corundum	topaz	9
10	diamond	garnet	10
		tantalum carbide	11
		tungsten carbide, fused aumina	12
		silicon carbide	13
		boron carbide	14
		diamond	15

Diamond has been promoted to 15 in the revised Moh scale. Because too many materials, such as the sintered carbides, rank between corundum (9) and diamond (10) the scale was revised to widen the spread and make the scale more linear in respect to absolute hardness. Both scales are given above.

In either system, materials are rated by scratching them against standards. For example, if the substance can scratch tantalum carbide but not tungsten carbide, its hardness is between 11 and 12. If it can scratch and be scratched by silicon carbide it is equal in hardness and is rated 13.





Thin edge is exactly 12 carbon atoms. Its dimension is 0.1 microin.—impossible in metal. Surface finish is less than 10 A or 0.04 microin. It is too fine to measure by multiple-beam interferometer. Diamond edge, bottom, is compared with honed razor blade, top, at 2000X.

of course, the hardness helps resist wear or scratching from other materials.

Coefficient of friction on a diamond-to-diamond surface is about 0.05—lower than any unlubricated bearing combination with the possible exception of Teflon-to-Teflon. The low friction characteristics allow diamond bearings to run at high speeds without lubrication or overheating. In one design, shafts speeds up to 90,000 rpm were possible. And because its carbon surface is polar, it attracts hydrocarbons, giving it excellent lubricant-retaining properties.

Diamonds are electrical insulators but their thermal conductivity is equal to that of many metals.

Chemical resistance is high because carbon is relatively inert. It is unaffected by strong alkalis and acids, including nitric and sulfuric acids. Heated oxidizing solutions affect it only slowly. For example, fused KNO_3 at 930 F etches diamond and shows its crystal pattern after an hour.

Diamond burns in oxygen but only when heated above 1500 F. In air it oxidizes slowly at 2800 F. It will retain most of its structural properties to beyond 2000 F if protected by inert atmospheres such as nitrogen or argon or a reducing atmosphere such as hydrogen. When heated to 3000 F, however, diamond begins to decompose into graphite.

At cryogenic temperature diamond is inert to such materials as liquid gases. Further, its low expansion coefficient is an advantage because it requires small allowances for expansion and contraction.

Diamond parts

Optimum size is usually limited to under 1 carat (about 0.003 cu in.) because larger diamonds are less common and price goes up rapidly. This restricts most applications to the miniature field. The techniques developed for working with tiny jewels are helpful here—diamonds as small as 0.0001 gm can be handled. For example a 50° cone with a diameter of 0.007 in. at the base and a tip radius of 0.0005 in. is quite common.

Externally ground shapes such as cones, cylinders and flats are the easiest to make. Internal surfaces and concave shapes are more difficult, and drilled holes are most difficult to make.

Diamonds are cheaper than you think if you must have reliable parts with long life. Because diamonds take high unit stresses, parts generally can be smaller. Costs can be lowered further by specifying diamonds only for critical points where wear or bearing

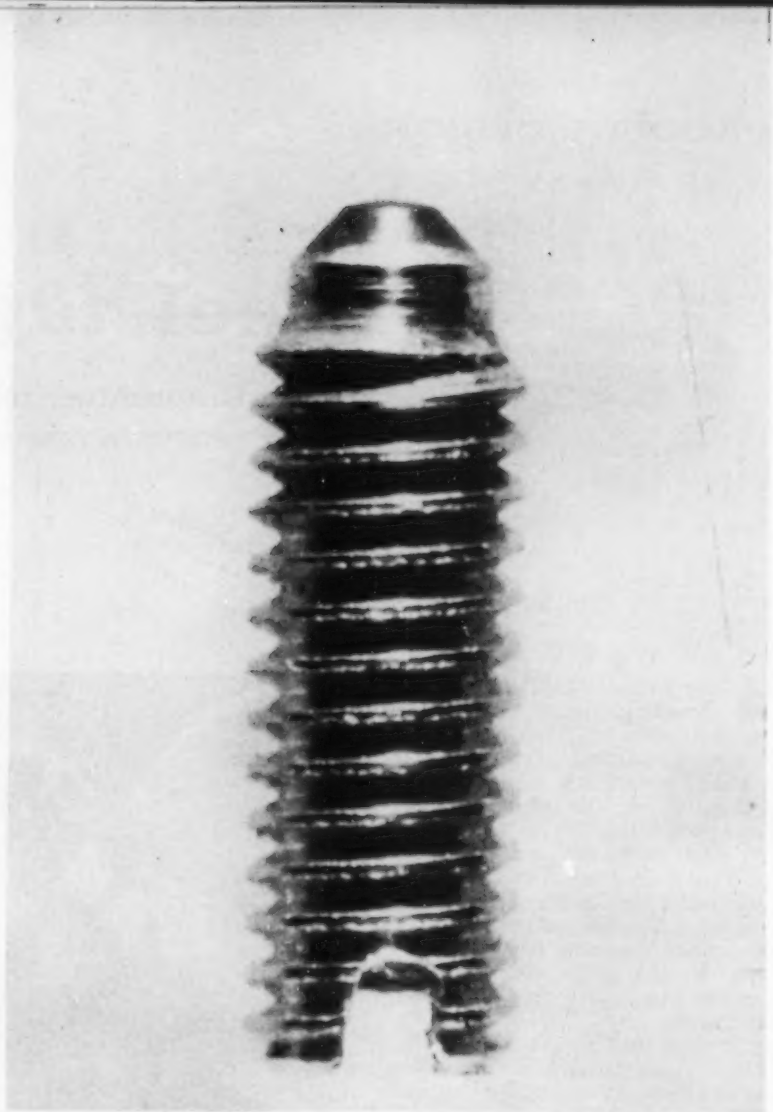
stress is too high for more common materials. Price of many diamond parts ranges from $3 to $15.

In practice, almost all of the diamond material is used because the raw stone selected is only slightly larger than the finished shape. If a curved surface is required, a round diamond would be used, if a polished disk is to be made, the part starts as a flat diamond.

Setting the diamond, or attaching it to a larger part is done in three ways: 1—Mechanical attachment by swaging or forming the metal around the diamond. 2—Brazing in vacuum or inert atmosphere or soldering with a hard solder. 3—Adhesive bonding with a thermosetting resin. (Here service temperature is severely limited because adhesives seldom retain useful strength above 300 F and are brittle below −50 F.)

Brazing is preferred to mechanical fastening because its high strength allows parts to be made with smaller diamonds. In addition, joints with brazed diamonds are less likely to become loosened by fluctuations in temperature. Adhesive bonding is usually limited to parts which cannot withstand brazing heat.

Contact area between the mating diamond parts must be several magnitudes smaller than the fastening area between diamond and metal so that the high loads will not indent the diamond into the metal. One method is to design the diamond with a spherical surface and allow it to wear its own perfectly matching bearing area on the mating part.



Diamond tip on screw maintains accurate adjustment for microswitch. Round diamond is brazed into metal and ground to shape. Contact surface at top of diamond has radius of 0.031 in. Diameter of metal screw is 0.092 in.

Editor's note: For more information on other aspects of meeting dimensional tolerances and combating wear in precision assemblies see these articles:

Need Precision? Don't Overlook Electroforming, Jun 5 '61, p 44—An up-to-date review of making parts by electroplating over a removable mandrel. Article gives the latest tricks on mandrel systems, plating alloys and design methods.

Practical Approach to Friction Coefficients, Sep 16 '60, p 51—A general table of friction coefficients and how to modify them to get the values you need.

Dimensional Stability in Precise Parts, Sep 12, '60, p 67—For mechanical parts that must meet dimensional tolerances within 1 to 5 microin. You must counteract the changes caused by service stress and temperature.

How to Avoid Abrasive Contamination of Precision Mechanical Devices, Aug 15 '60, p 51—Minute particles 1 to 5 microns dia start failures in precision mechanisms. These particles, not even visible at magnifications of 200X, require special cleaning techniques.

How to Predict Wear Life of Rolling Surfaces, May 9 '60, p 44—Load-stress K factors for various material and hardness combinations simplify life-expectancy calculations for gears, cams, bearings, clutches, and links.

Press-fit Test Picks Solid Lubricants for Extreme Pressures, Jun 22, '59, p 64—A simple way to find coefficient of friction when surfaces slide at high loads and low velocities. Charts list values for over 50 candidates.

Wear of Lubricated Surfaces, Apr 13 '59, p 74—Report of ASME symposium covers recently developed techniques on isotope tracers, wear coefficients, gear-tooth profiles and engine additives.

ASLE Gear Symposium, Feb 16 '59, p 64—Staff report reveals some unusual thinking on wear of oscillating parts, leading to a generalized wear equation for type motion.

More Surface Polishing—Less Galling, Nov 24 '58, p 63—Shows why parts should be "worn in" before they take loads and why cast irons are less likely to gall than steels or brasses.

Considerations for Friction Materials, Mid-Sep '58, p C16—Discusses nature of friction materials, their characteristics and how to choose them.

Predict Wear of Metal Parts, June 23 '58, p 71—Presents new design coefficients to account for galling; discusses conditions of lubrication, surface cleanliness and surface cracks.

—Herbert Kee

Steel tapes locate

Differential linkages convert key selection into type head positions.

A single print element bearing 88 characters replaces conventional type bars. The type head, a truncated sphere, is attached to a head and rocker assembly and mounted on a sliding carrier. The carrier and type head move from left to right down the length of the stationary platen.

When the operator touches a key a system of linkages and steel tapes tilt and rotate the type head to move the selected character into print position. The character is printed by rocking the type head against the ribbon and paper.

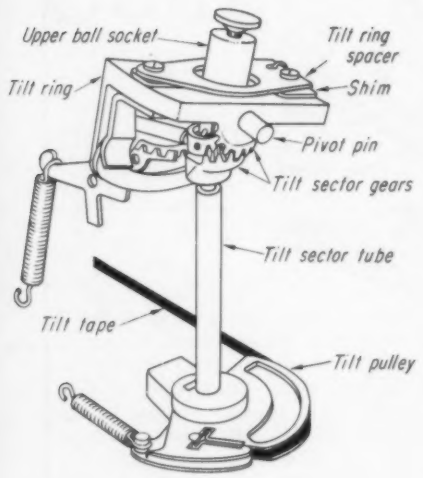
The type head contains 4 bands with 22 characters per band. It is positioned around two axes, one through the poles (rotation) and another through the equator (tilt). These motions occur simultaneously when a letter key is depressed.

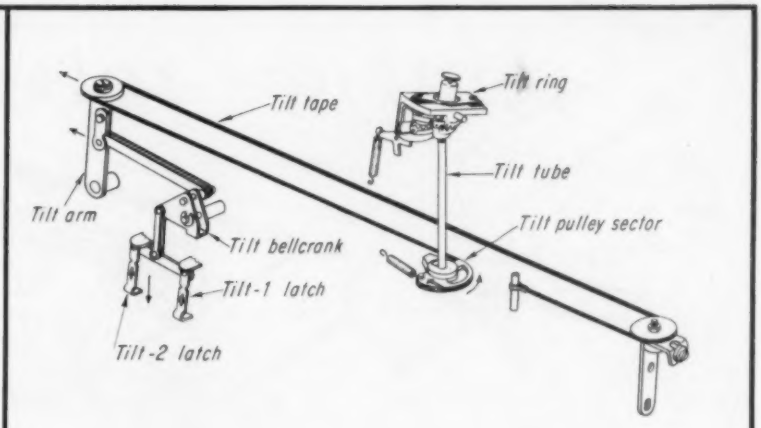
Total weight of the carrier is about one pound compared to the 8 or 9 lb for a conventional carriage. The low weight of the moving elements permits the typewriter to print up to 186 words per minute.

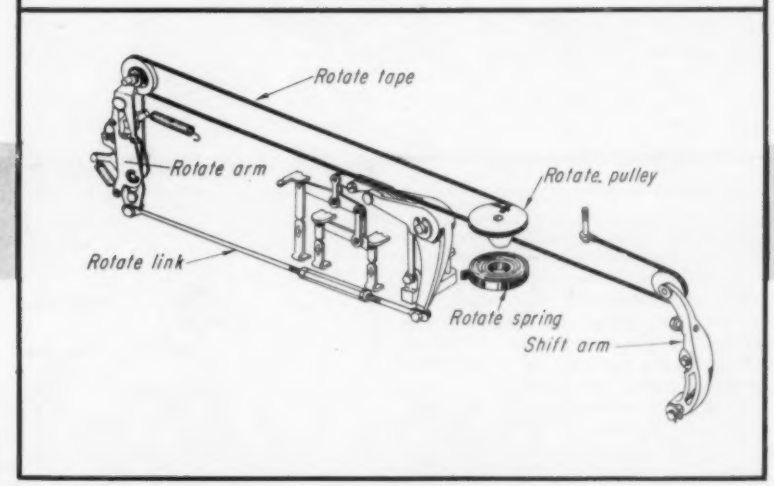
The type head snaps on and off easily allowing any of the six type faces available to be changed by the operator. Model 721 will accept paper up to 11 in. wide and has a 8½ in. writing line. Model 725 accepts paper up to 15½ in. wide and has a 13 in. writing line. The Selectric is produced by IBM Electric Typewriter Division, Lexington, Ky.

Beginning in 1956, industrial designer Eliot Noyes, ASID, worked with the IBM design staff on the Selectric. His comments: "Where conventional typewriters need large holes in the sides for the carriage to move back and forth, the new machine permitted the form to be a single complete shape. In design therefore, we tried to emphasize singleness and simplicity by making the shape something like that of a stone so that you are aware of the continuity on sides, bottom and top. This also dramatizes the fact that there is no carriage. Scoops are taken out for keyboard and platen, and some areas are slightly eroded on the sides to locate the platen knobs, but they only embellish the form and do not in any way destroy its simplicity. New keys were designed and other details added to improve the usefulness of the machine to the typist."

88-character type head



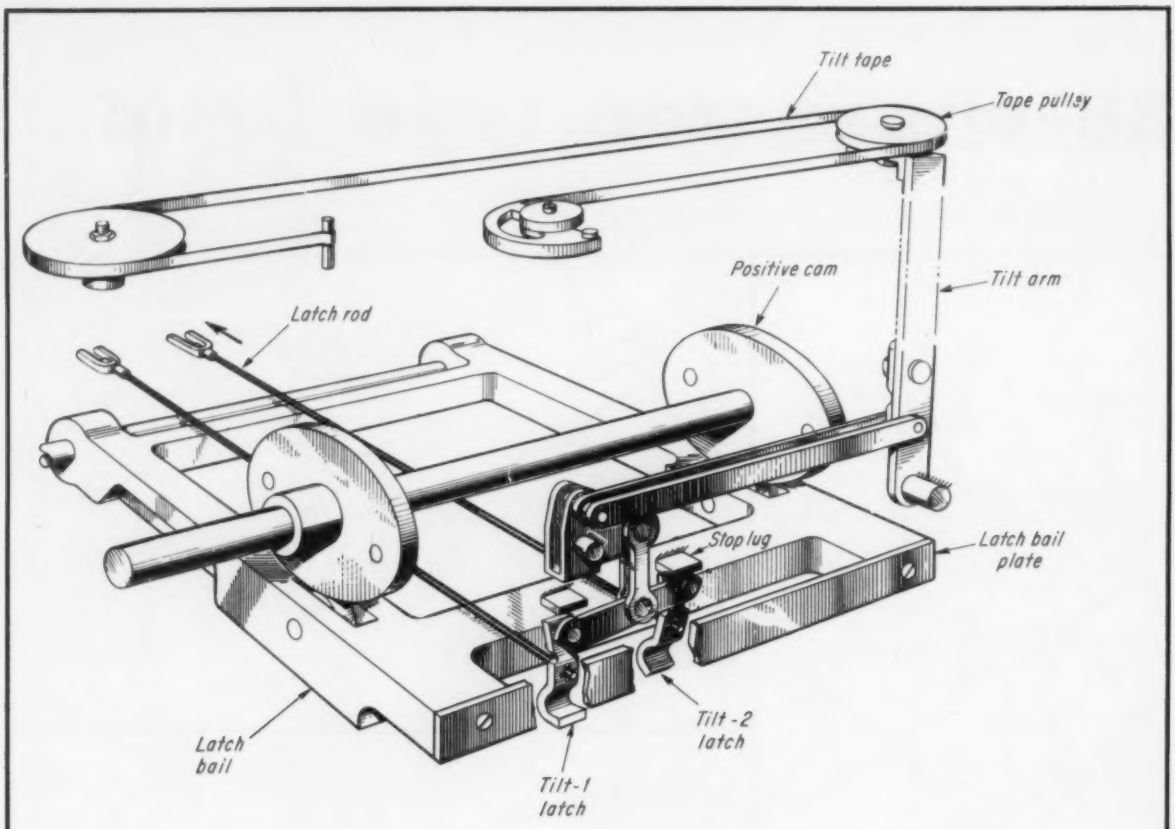


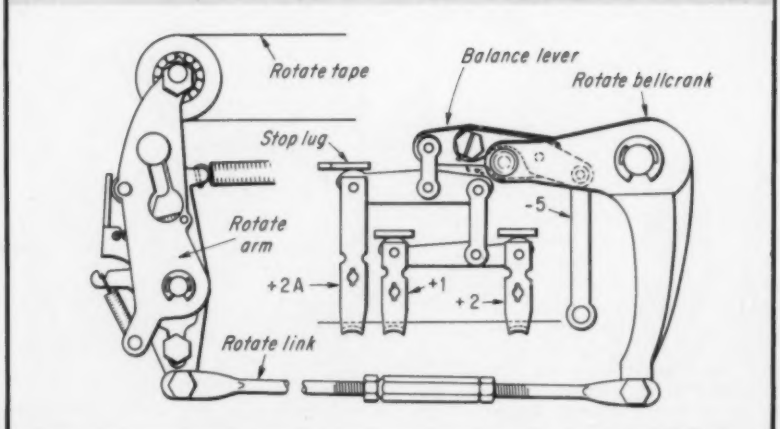


All positioning motions occur while the type head is moving toward the platen to print. Tilt motions are produced by pivoting the tilt ring which supports the upper ball socket and type head. The tilt ring is driven by a pulley sector through beveled sector gears and a tube Tne tilt tape is wrapped around and connected to the pulley. When the tape is pulled it rotates the sector and tilt tube counterclockwise and tilts the type head. When the pull on the type is relaxed the sector and type head are returned by spring to rest position.

From the sector, tape extends to the left around a horizontal idler pulley, back to the right around a second idler and is then attached to the carrier. When a tilt operation is required, the distance between the two idler pulleys is increased by moving one of the pulleys. This produces the necessary pull on the tilt tape. To rotate the sector and tube which activates the tilt ring. Thus the carrier may be at any location along the platen without affecting type head position. The right-hand idler pulley is fixed; the left-hand idler is mounted on a pivoting arm. Movement of the arm to the left exerts a pull on the tilt tape, rotating the tilt tube and tilting the head.

Rotate system also uses a tape to control the position of a shaft which passes through the tilt tube. The upper end of the shaft is connected to the upper ball socket by a dog-bone ball joint. This permits the ball socket on which the type head is mounted to tilt and rotate at the same time. In the rotate system the idler pulleys turn in a vertical plane and both support arms can pivot. The rotate arm, at left, can be pivoted left or right to produce type head rotation to locate five characters on either side of the rest position. The shift arm, at right, spins the type head 180° from the selected letter for capital letters and symbols. *(continued, next page)*





Differential linkages which control the tilt and rotate tapes are actuated by a series of latches. Two latches control tilt while four rotate the type head. The latches hook under the bail plate and are held in place by springs. They are actuated when the latch bail is depressed by rotation of the positive cam.

Each latch is connected to the character selection elements in the keyboard by its latch rod. When the latch rod is pulled it disconnects the latch from the bail plate. By a process of selective elimination of latches any combination of tilt and rotate can be achieved.

The tilt latches are connected through levers, links and a bellcrank to the tilt arm on which the tape pulley is mounted. When the tilt—2 latch rod is actuated its latch is pulled clear of the bail plate. When the cam rotates the tilt—1 latch is pulled down while the tilt—2 latch rests against its stop lug. The vertical link is attached to the lever one third of distance between latch pivot. Thus the vertical link moves down one third of the distance the bail moves. The movement is transmitted through tilt bellcrank and arm to the pulley, producing a one-band tilt.

When the tilt—2 latch is operated (the tilt—1 latch withdrawn) the vertical link moves two-thirds as much as the bail, producing a two-band tilt. If neither latch is withdrawn both latches are pulled down. The vertical link moves the same distance as the bail, producing a three band tilt.

The rotate linkage has four latches. The +1, +2 and +2A latches are used singly or in combination to produce positive rotation of up to 5 characters. Negative positioning is accomplished by a separate bail operating a −5 link. The −5 link produces clockwise movement of the bellcrank resulting in a 5 character negative rotation of the type head. This is used with the positive latches to produce negative positions of less than 5.

Deflections and stresses of
Complex flat springs

Equations for twelve basic types—plus
a simplified method applicable to wider variety of shapes.

ALEXANDER BLAKE, technical specialist, Aerojet-General Corp, Sacramento, Calif

THE COMPLEX analysis usually called for in predicting deflections of complex-shape springs under given loads is frequently avoided by having a sample spring built in the shop and then subjecting it to tests. Aside from the obvious time and cost considerations (the first or second design seldom serve), this approach has the disadvantages of: (1) not predicting the maximum stress—a requirement if a safety factor is to be known or where fatigue is involved; (2) the sample springs subtly differ from those made later by mass production techniques —frequently leading to failures or undesirable performance.

To simplify the analytical approach, design equations for finding the deflections and maximum stresses of twelve basic types of complex springs are given here. These springs consist of circular elements, straight elements connected by small radii and springs with both circular and curved portions.

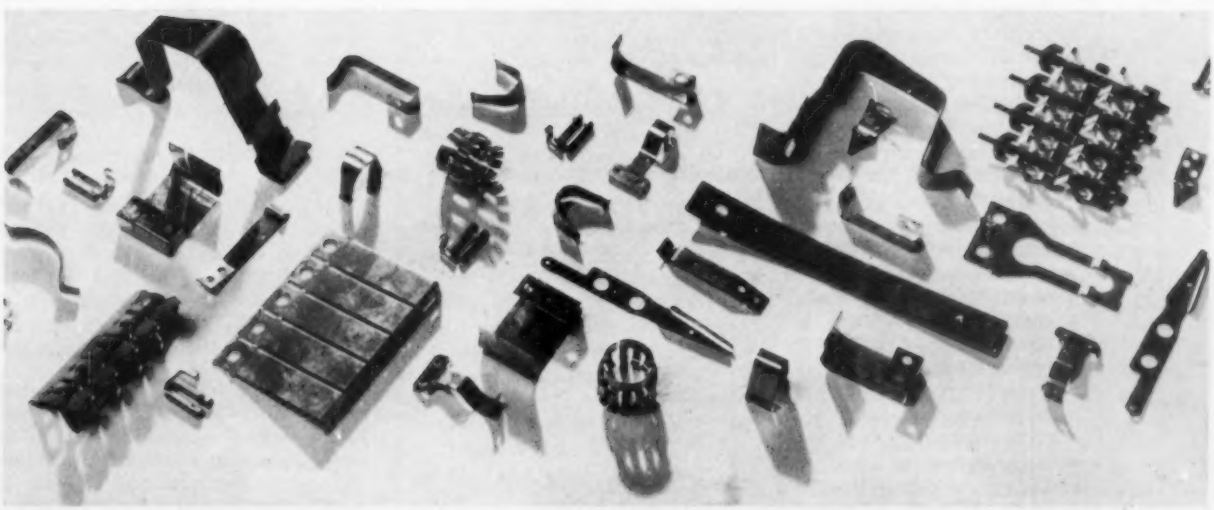
In addition, key steps in deriving these equations are included to guide the designer in the development of equations for shapes not analyzed in this article. Three sample problems illustrate how to apply the equations to springs with contours that differ somewhat from those of the basic types.

It is assumed that the springs are sufficiently stable laterally so that only bending in the plane of curvature requires attention, and that the theory of pure flexure and Hooke's law apply.

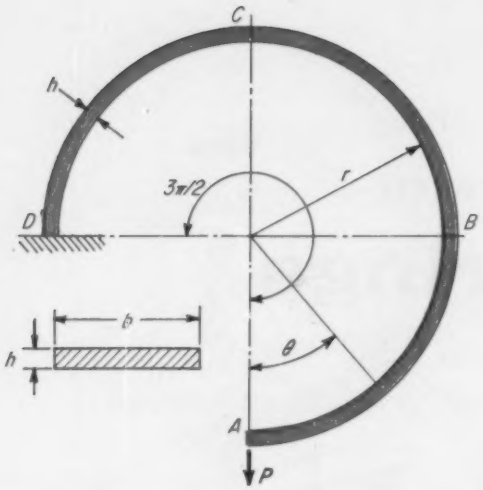
CIRCULAR BENDS

1. Three-quarter circular spring

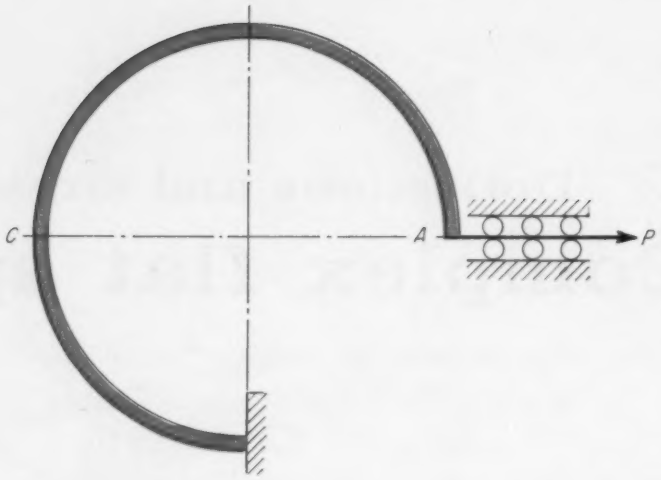
The bending moment at any point on the circular spring in Fig 1, in



Typical complex spring forms—here produced in heat-treated beryllium copper by Instrument Specialties Co Inc.



1 Three-quarter circular spring



2 Three-quarter circular spring, constrained motion

terms of θ measured from line AC, is

$$M = Pr \sin \theta \qquad (1)$$

Note from this equation that there is zero bending moment and zero bending stress at points A and C where $\sin \theta$ is zero. Also the two regions of maximum bending moment are at B and D where $\sin \theta = 1$. Therefore, the maximum bending stress can be obtained directly from the relation $S = M/Z$, where Z denotes elastic section modulus. For a rectangular section:

$$Z = \frac{I}{C} = \frac{bh^3}{12} \Big/ \frac{h}{2} = \frac{bh^2}{6}$$

Thus

$$S = 6Pr/bh^2 \qquad (2)$$

Shear stresses are present at the points of zero bending moment—however, their contribution to the stresses and strains in this particular case is negligible because the structure is sufficiently slender.

Derivation of the equation for the deflection under load, P, can be accomplished by using Castigliano's theorem which, incidentally, is much more frequently employed in Europe than here in America. The theorem states that the displacement of a structural member measured in the direction of the applied load, P, is equal to the partial derivative of the total elastic strain energy of this member with respect to the load, P. Because we are dealing here with so called slender members it is only necessary to take into account the elastic strain energy caused by bending. The statement of Castigliano's principle in polar coordinates applicable to this case is:

$$Y = \frac{1}{EI} \int M \frac{\partial M}{\partial P} r \, d\theta \qquad (3)$$

Hence, differentiating Eq (1) and utilizing Eq (3), gives the vertical deflection, Y, under load, P.

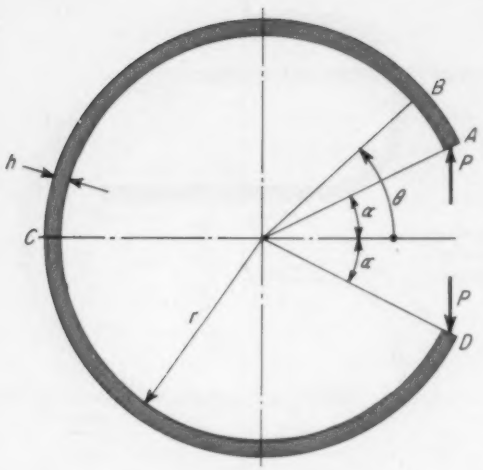
$$Y = \frac{3\pi Pr^3}{4EI} \qquad (4)$$

2. Three-quarter spring—constrained

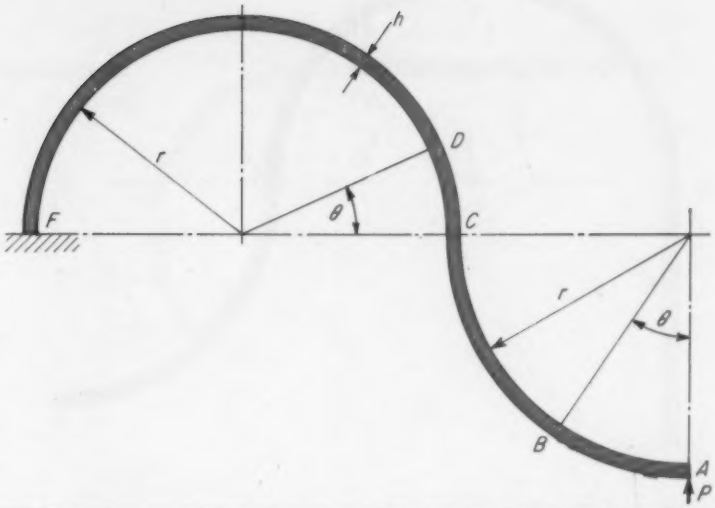
In some applications, the free end of the three-quarter circular spring is constrained by guides, Fig 2, to move in a line coincident with line AC only. The previous analysis is modified by introducing a constraining couple, M_o, as a redundant quantity.

SYMBOLS

a, c, d = straight lengths of spring including corner radii, in.
b = width of cross-section of flat strip, in.
C = distance from neutral axis to extreme fiber, in.
E = modulus of elasticity, psi
G = deflection factor depending on K and β (equal to the factors inside the bracket of Eq 30)
h = thickness of strip cross-section, in.
I = moment of inertia of strip cross-section, in.^{4}
J = deflection ratio
K, N = length ratios, L/r
L = length of straight portion of complex-shaped spring, in.
M = bending moment, lb-in.
M_o = fixing couple, lb-in.
P = concentrated external load, lb.
r = mean radius of curvature, in.
S = bending stress, psi
x = distances along straight portions, in.
Y = deflection, in.
Z = section modulus of strip cross-section, in.^{3}
α = angle in radians
β = angle subtended by curved portion of spring, rad
θ = angle at which bending moment is considered, rad



3 Snap-ring spring



4 Three-quarter circular-wave spring

Hence, the modified bending moment is

$$M = Pr \sin \theta - M_o \qquad (5)$$

Because of the constraint, the angle of rotation of the loaded end is zero. By the Castigliano's principle we have

$$\int M \frac{\partial M}{\partial M_o} r \, d\theta = 0 \qquad (6)$$

Therefore, employing Eq (5) together with Eq (3) and (6), the deflection of the guided end becomes

$$Y = \frac{Pr^3}{EI}\left(\frac{9\pi^2 - 8}{12\pi}\right) \qquad (7)$$

Comparing Eq (7) with Eq (4) indicates that the effect of the guide-constraint in this particular case is small. However this effect changes with the angle of spring-arc, and if desired, may be investigated with the aid of the above equations.

3. Snap-ring spring

Because of symmetry in the snap-ring type leaf spring, Fig 3, it is sufficient to analyze one half of the spring, such as from *A* to *C*. The bending moment equation with reference to point *B* is

$$M = Pr(\cos \alpha - \cos \theta) \qquad (8)$$

For a given value of α, the expression for the maximum bending stress becomes

$$S = \frac{6Pr(1 + \cos \alpha)}{bh^2} \qquad (9)$$

The total amount of deflection (change in distance *AD*) caused by the loads acting at the free ends equals twice the deflection of one half of the spring. Introducing the expression for bending moment, Eq (8), and its partial derivative with respect to P into the Castigliano equation, Eq (3), and extending the integration between the limits of α and π, results in the following deflection equation:

$$Y = \frac{Pr^3}{EI}\left[(\pi - \alpha)(1 + 2\cos^2 \alpha) + \frac{3}{2}\sin 2\alpha\right] \qquad (10)$$

Here, *Y* denotes the total change in distance *AD* resulting from forces *P*. This equation is also applicable when the direction of end loading is reversed.

4. Three-quarter circular-wave spring

When the shape complexity of the leaf spring is progressively increased similar analyses to those of the two previous cases can be made without difficulty. Consider a leaf-type spring formed in a three-quarter circular wave, fixed at one end and subjected to a concentrated vertical load *P* at the other, Fig 4. Portions *AC* and *CF* are analyzed separately. Corresponding moments are:

Part *AC* $M = Pr \sin \theta \qquad (11)$

Part *CF* $M = Pr(2 - \cos \theta) \qquad (12)$

The maximum bending stress occurs at fixed end *F* and is equal to

$$S = \frac{18Pr}{bh^2} \qquad (13)$$

Total resilience of the spring is the algebraic sum of the two component values of resilience corresponding to the portions *AC* and *CF*. Therefore employing Eq (3), (11) and (12) gives

$$Y = \frac{Pr^3}{EI}\int_0^{\pi/2} \sin^2 \theta \, d\theta + \frac{Pr^3}{EI}\int_0^{\pi} (2 - \cos \theta)^2 \, d\theta$$

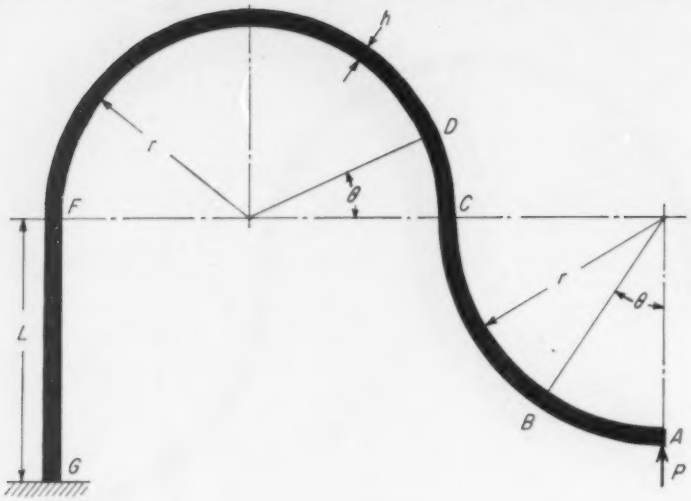
Integrating this equation gives the design formula for the deflection under load, *P*:

$$Y = \frac{19\pi Pr^3}{4EI} \qquad (14)$$

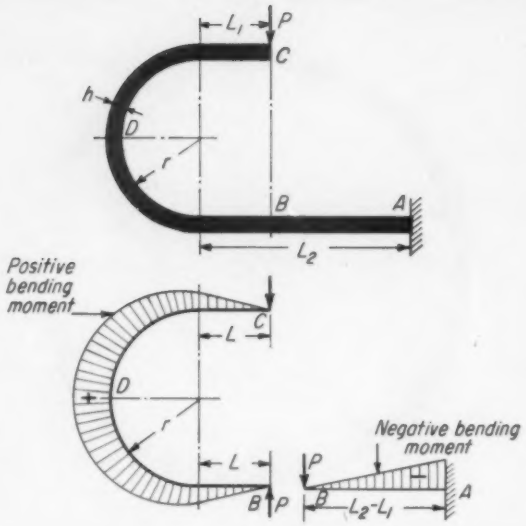
5. Circular-wave spring with extension

Adding a straight portion of length, *L*, to the three-quarter circular-wave spring, Fig 5, does not influence the formula for the maximum bending stress, Eq (13). The reason for this is that the extension *FG* acts as a cantilever beam, built-in at *G*, and loaded by a couple (*3PR*) at *F*. Also, the effect of direct stress caused by load *P* can be safely ignored because bending stresses in a slender structure predominate.

The deflection formula for the modified spring, however, should be corrected by considering additional re-



5 Circular-wave spring with extension



6 U-spring, short extension ($L_1 < L_2$)

silience of cantilever *FG* subjected to end couple. When this is done the deflection formula becomes

$$Y = \frac{Pr^3}{EI}\left[9\frac{L}{r} + \frac{19\pi}{4}\right] \quad (15)$$

COMPLEX CANTILEVERS

Flat springs of a cantilever type, consisting of precurved and straight portions, are often employed as retaining brackets, holding clamps, loading members and other similar components. The curved portions in production are usually approximated by circular arcs; therefore, design formulas developed on the assumption of circular curvature become sufficiently accurate for most practical purposes.

In calculating the deflections of complex-shape springs, the concept of a developed length is often introduced, thereby neglecting the true effect of the curvature. It will be shown here by analysis that this concept can lead to serious errors for certain portions of the springs.

The stress and deflection study of complex-shape springs should first include a sketch of the bending moments. The investigation of the bending moment distribution along the contour of the spring helps locate the regions of zero bending moments or zero slopes so that the structure can be subdivided into simpler components for the purpose of analyzing the deflection. The total deflection can then be obtained by the method of superposition—provided the elastic limit of spring material is not exceeded.

6. U-spring, short extension

Consider the U-spring in Fig 6. The distribution of the bending moment is also shown. The displacement of the loaded end *C* is obtained by the method of superposition of the component deflections. The deflection of a symmetrical U-spring *BC* is:

$$Y_{BC} = \frac{Pr^3}{EI}\left[\frac{2K^3}{3} + \pi K^2 + 4K + \frac{\pi}{2}\right] \quad (16)$$

where $K = L_1/r$

The deflection of a straight cantilever beam *AB* of length $(L_2 - L_1)$ is given by the standard formula

$$Y_{AB} = \frac{P(L_2 - L_1)^3}{3EI} \quad (17)$$

Employing the method of superposition, the total deflection under the transverse load, *P*, becomes:

$$Y = \frac{Pr^3}{EI}\left[\frac{N^3 + K^3}{3} + K^2(N + \pi) + K(4 - N^2) + \frac{\pi}{2}\right] \quad (18)$$

Here

$N = L_2/r$; and $K = L_1/r$

Maximum bending stress in this type of spring is either at *A* or *D*, depending on spring proportions. Therefore:

When $(L_2 - L_1) > (L_1 + r)$

$$S = \frac{6P(L_2 - L_1)}{bh^2} = \frac{6Pr}{bh^2}(N - K) \quad (19)$$

when $(L_2 - L_1) < (L_1 + r)$

$$S = \frac{6P(L_1 + r)}{bh^2} = \frac{6Pr}{bh^2}(1 + K) \quad (20)$$

7. U-spring, long extension

When $L_2 = L_1$, a symmetrical U-shape spring is obtained whose deflection and maximum bending stress can be computed from Eq (16) and (20), respectively. However when $L_1 > L_2$, Fig 7, the spring cannot be divided into symmetrical components and therefore it is necessary to analyze the spring in three separate stages as follows:

Part *AB* $M_1 = Px_1$ (21)

Part *BC* $M_\theta = P(L_1 + r\sin\theta)$ (22)

Part *CD* $M_2 = P(L_1 - x_2)$ (23)

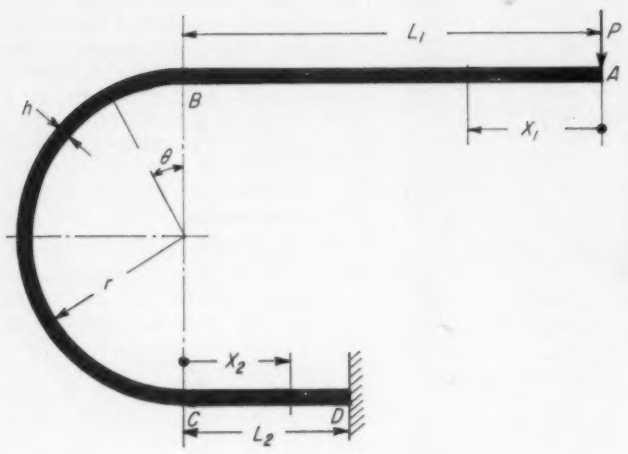
The principle of Castigliano expressed in Eq (3) can be written in rectangular-coordinate form:

$$Y = \frac{1}{EI}\int M\frac{\partial M}{\partial P}\,dx \quad (24)$$

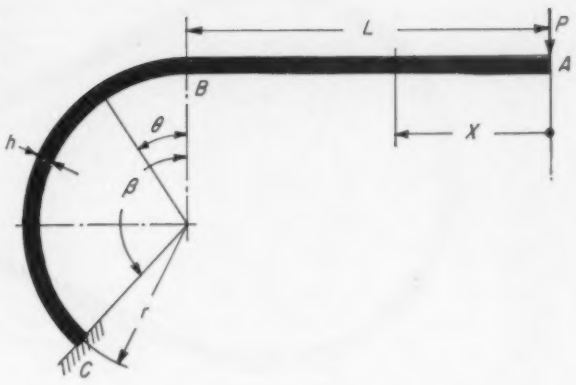
Hence, the total deflection under load, *P*, can be derived from the following expression:

$$EI\,Y = \int_0^{L_1} M_1\frac{\partial M_1}{\partial P}\,dx_1 + \int_0^{\pi} M_\theta\frac{\partial M_\theta}{\partial P}\,rd\theta + \int_0^{L_2} M_2\frac{\partial M_2}{\partial P}\,dx_2 \quad (25)$$

Integration of this equation results



7 U-spring, long extension ($L_1 > L_2$)



8 Curved-end cantilever spring

in the equation for deflection (in this particular case) identical with Eq (18). The maximum bending stress for this type of spring is always given by Eq (20), provided the condition $L_1 \geqq L_2$ exists. The derivation methods discussed in relation to the springs in Fig 6 and 7 can be extended to a wide variety of complex-shaped springs. The procedure shows the importance of the preliminary analysis of the distribution of bending moment and the convenience of the Castigliano principle coupled with the method of superposition.

8. Curved-end cantilever spring

The complex-shaped springs discussed so far included curved portions which could be approximated by half-circles. For springs with circular arcs less than 180°, it is necessary to treat a more general case of a curved-end cantilever. A more general case is also helpful in evaluating the extent of the error in calculation of the deflection analyzed on the basis of the developed-length method which calculates the unwound length and treats the shape as a straight cantilever.

A general case of a curved-end cantilever spring is shown in Fig 8. The bending moment acting at any point along the straight portion AB, is

$$M = Px \tag{26}$$

and along the curved portion BC, it is

$$M = Pr(K + \sin\theta) \tag{27}$$

The bending moment at the built-in end attains the maximum value only if $\beta \leqq \pi/2$; thus the stress becomes

$$S = \frac{6Pr(K + \sin\beta)}{bh^2} \tag{28}$$

When the subtended angle β varies between $\pi/2$ and π, the maximum bending stress becomes

$$S = \frac{6Pr(1 + K)}{bh^2} \tag{29}$$

The deflection of the free end under load, P, is obtained by the integration of Eq (3) and (24) with the aid of the bending moment expressions, Eq (26) and (27). This gives

$$Y = \frac{Pr^3}{EI}\left[\frac{K^3}{3} + K^2\beta + 2K(1 - \cos\beta) + \frac{\beta}{2} - \frac{\sin 2\beta}{4}\right] \tag{30}$$

For $\beta = \pi/2$, Eq (30) gives half of the deflection computed from Eq (16) derived for U-shape spring. For simplicity, the factors inside the bracket of Eq (30) are denoted by the letter G. Hence, Eq (30) becomes

$$Y = \frac{Pr^3}{EI} G \tag{31}$$

Factor G denotes the deflection factor depending on the length ratio, K, and subtended angle, β. Suppose now that instead of the exact equation, Eq (31), the approximate cantilever formula together with the concept of "developed length" are used. The developed length is equal to $L + \beta r$ or, in terms of K, $r(K + \beta)$. Hence the deflection would become:

$$Y = \frac{Pr^3(K + \beta)^3}{3EI} \tag{32}$$

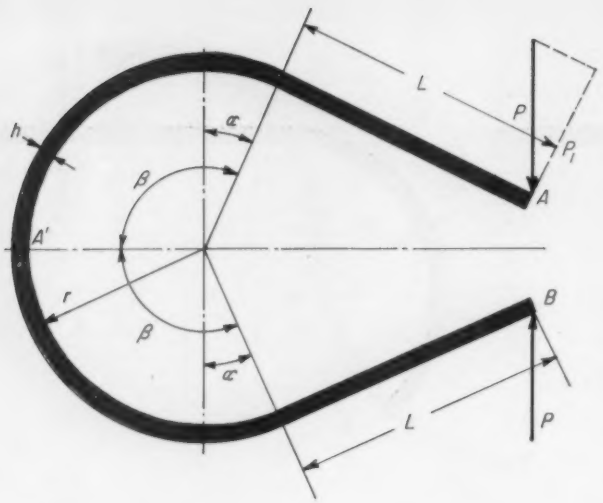
If J denotes the deflection ratio obtained by dividing Eq (31) into (32), we find that

$$J = \frac{3G}{(K + \beta)^3} \tag{33}$$

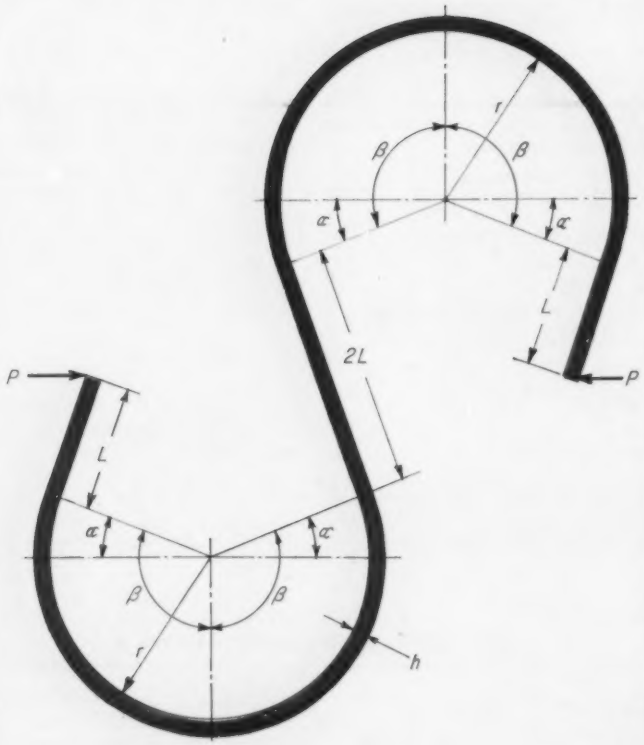
Factor J is the correction factor

Developed Length Correction Factor, J

	K = L/r							
β (deg)	0.2	0.6	1.0	2.0	4.0	6.0	8.0	10.0
45	0.92	0.95	0.97	0.98	0.99	0.99	0.99	1.00
90	0.66	0.75	0.81	0.89	0.96	0.98	0.99	0.99
135	0.39	0.52	0.60	0.73	0.87	0.92	0.95	0.96
180	0.19	0.29	0.38	0.54	0.73	0.83	0.88	0.91



9 Closed U-spring



10 S-spring

which is a complex function of K and β. It gives an indication of the calculation error caused by the assumption of the developed length. Some representative values of J are shown on p 55. Thus for a spring of the proportions shown in Fig 8, the developed-length method results in a value only 81% accurate ($B = 115°$, r = 7/8, $L = 1\frac{7}{8}$; hence $K = 2.43$ and $J = 0.81$).

9. Closed U-spring

The theory developed for a general case of a curved-end cantilever can be applied directly to the closed U-spring, Fig 9. However, for Eq (30) to become applicable the following modifications must be made. Let the component force P_1 act perpendicular to the straight portion, L, as shown in Fig 9. Then

$$P_1 = P \cos \alpha \qquad (34)$$

If Y_1 denotes displacement of loaded end A in the direction of P_1, and Y the total change in the distance AB resulting from P, then

$$2Y_1 = Y \cos \alpha$$

or

$$Y_1 = \frac{Y}{2} \cos \alpha \qquad (35)$$

The deflection caused by load P_1 is obtained directly from Eq (31). Introducing the modified notations gives

$$Y_1 = \frac{P_1 r^3}{EI} G$$

Substituting Eq (34) and (35) into the above equation results in the final deflection formula for the closed U-spring:

$$Y = \frac{2Pr^3}{EI} G \qquad (36)$$

Thus, in this particular case the deflection under the load P is independent of α. However, when the maximum bending stress is considered, α appears in the relevant design formulas. For $\beta = \pi/2 + \alpha$, the expression for the maximum bending stress at A' becomes:

$$S = \frac{6Pr}{bh^2} (1 + \sin \alpha + K/\cos \alpha) \qquad (37)$$

When $\alpha = 0$, Eq (37) reduces to Eq (29). On the other hand when $\beta \leqq \pi/2$, the stress is given by the equation.

$$S = \frac{6Pr}{bh^2} (1 - \cos \beta + K' \cos \alpha) \qquad (38)$$

When $\alpha = 0$, $\beta = \pi/2$ and Eq (38) reduces to Eq (29). If desired, Eq (37) and (38) can be easily rearranged through the following substitutions: $\alpha = \beta - \pi/2$ and $\alpha = \pi/2 - \beta$, respectively. The spring proportions limit α to a value obtained from the

geometrical relation, cot $\alpha = K$, provided load P is zero. For a specified deflection Y and $\beta = \pi/2 + \alpha$ the limiting value becomes:

$$Y = 2r\,(\cos\alpha - K\sin\alpha) \qquad (39)$$

Equating Eq (36) and (39) gives

$$P = \frac{EI}{Gr^3}\,(\cos\alpha - K\sin\alpha) \qquad (40)$$

This equating gives the value of P at which the deflected ends will touch without exerting any pressure. This condition can be accepted only if the corresponding bending stress, given by Eq (37), does not exceed the elastic limit of the material.

10. S-spring

The total amount by which the free ends of the S-spring in Fig 10 approach each other under load P follows directly from Eq (36)

$$Y = \frac{4Pr^3}{EI}\,G \qquad (41)$$

The maximum bending stresses can be computed from Eq (37) and (38). Eq (39) and (40) are also applicable.

SHARP CURVATURE SPRINGS

Where springs involve relatively long straight portions and sharp radii of curvature, such as in Fig 11 and 12, the preceding analyses must be applied cautiously. Sharp radii cause stress concentrations. There exists a considerable amount of design data in the literature on this particular aspect of structural behavior. In general, stress raisers are characteristic of elastic behavior. Plastic yielding reduces the effects of stress concentration so that the practical significance of this problem depends on circumstances. Ductile material under static loading is usually not sensitive to stress raisers. With brittle materials stress concentration is generally a serious consideration—but the susceptibility to failure varies with the type of brittle material. The conditions involving fatigue also have considerable influence on breaking strength in presence of various type of stress raisers and even ductility can prove to be a poor measure of immunity to stress concentration.

In the springs of Fig 11 and 12 rather rapid stress variation is brought about by a curved beam effect of relatively small radius at the corners. The unit stresses in a beam of this type are not directly proportional to the distance of the neutral axis because the length of the elementary filaments are not identical. As a practical guide, as long as the ratio of depth of section to inner radius of the fillet is not more than about 0.5, the approximate method of stress calculation should yield acceptable results for most design purposes. Also, in calculating the deflections, the ratios of straight length to radius of curvature are usually quite large so that the effect of corner radii can be safely ignored.

11. Sharp-bend cantilever spring

The bent cantilever spring in Fig 11 can be subdivided into three portions, a, c and d. The corresponding bending moment equations expressed in terms of load P are as follows:

$$M_a = -Px \qquad (42)$$

$$M_c = Pa \qquad (43)$$

$$M_d = P(a - x) \qquad (44)$$

Utilizing the general equation, Eq (24), the total displacement of the loaded end of the spring in the direction of P is

$$EI\,Y = \int_0^a M_a \frac{\partial M_a}{\partial P}\,dx + \int_0^c M_c \frac{\partial M_c}{\partial P}\,dx + \int_0^d M_d \frac{\partial M_d}{\partial P}\,dx \qquad (45)$$

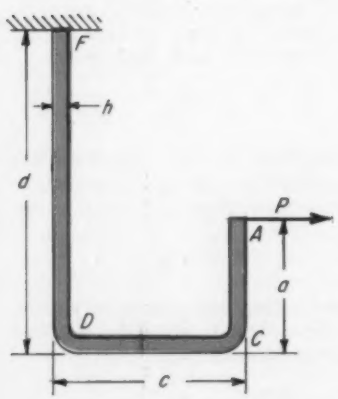
This equation illustrates the general procedure to be followed when the complex-shape spring can be subdivided into a number of regions to which particular bending moment relations apply. Because a, c and d can be varied arbitrarily in this case, the position and the magnitude of the maximum bending stress can be determined by inspection. Introducing Eq (42), (43) and (44) into (45) and integrating gives

$$Y = \frac{P}{3EI}\,(a^3 + 3a^2c + 3a^2d - 3ad^2 + d^3) \qquad (46)$$

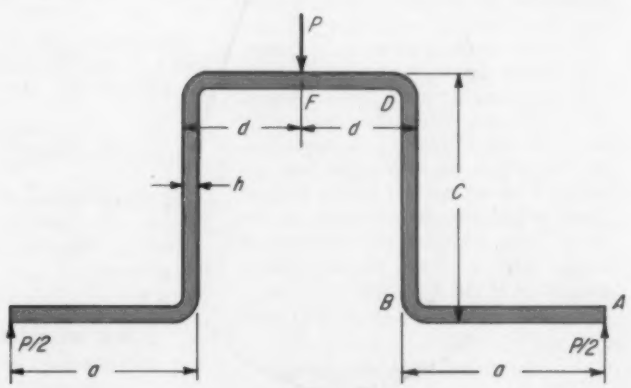
This equation is applicable also to cases where $a = 0$, $a = c = 0$, $d = 0$ or $d = c = 0$, giving various design formulas for the calculation of the deflection.

12. Frame-type spring

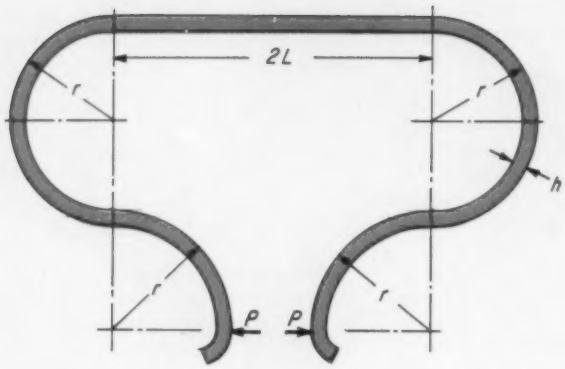
When a frame-type leaf spring, Fig 12, is loaded symmetrically, there must be a zero slope at F. This permits analysis of only one half of the struc-



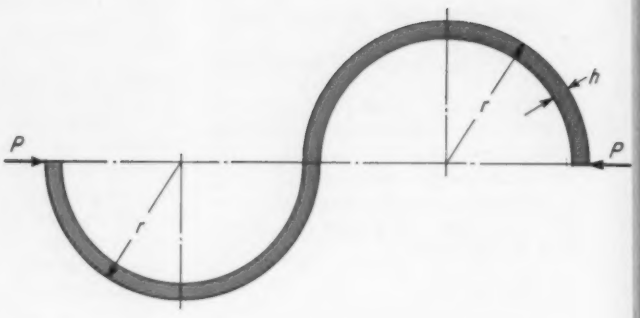
11 **Sharp-bend cantilever spring**



12 **Frame-type spring**



13 Clip spring



14 Half-circle S-spring

ture, and the bending moments become:

$$M_a = Px/2 \quad (47)$$

$$M_c = Pa/2 \quad (48)$$

$$M_d = P(a + x)/2 \quad (49)$$

The derivation can be carried out with the aid of Eq (45) giving the following deflection formula

$$Y = \frac{P}{6EI}[(a + d)^3 + 3a^2c] \quad (50)$$

In developing Eq (50) it is assumed that the corner radii are relatively small and can be neglected. In practice, sharp corners are not absolutely rigid. However, when analyzing the deflection, the effect of such corners can be neglected. Location of the maximum bending stress in a frame-type spring should be determined with regard to possible stress concentrations at the corners. When the corner radii are sufficiently large to be neglected, the maximum bending stress will occur at F under normal spring proportions. However, in addition to the above considerations the question of elastic stability of the vertical sides c may arise if the horizontal portions a and d are found to be relatively small.

DESIGN EXAMPLES

Example I—Circular Bends

The complex-shaped flat spring made of spring steel, Fig 13, is employed as a clip, going over a machine member by spreading apart the free ends. Calculate the maximum bending stress for a spring with the following requirements:

Mean radius of curvature	$r = 0.5$ in.
Straight portion	$2L = 1.5$ in.
Thickness of stock	$h = 0.040$ in.
Deflection of free ends	$2Y = 0.2$ in.
Modulus of elasticity	$E = 30 \times 10^6$ psi

Solution:

The stress and deflection formulas applicable to this case are given by Eq (13) and (15), respectively. Because the load acting on the spring is not known, Eq (13) is rearranged:

$$P = \frac{Sbh^2}{18r}$$

Introducing the above expression, and $I = bh^3/12$, into Eq (15) gives the equation for maximum stress:

$$S = \frac{6EhY}{r^2(36N + 19\pi)}$$

By the definition, $N = L/r = 0.75/0.5 = 1.5$. Hence, substituting the numerical data, the maximum bending stress is:

$$S = \frac{6 \times 30 \times 10^6 \times 0.040 \times 0.1}{0.25\,(36 \times 1.5 + 19 \times 3.14)} = 25{,}300 \text{ psi}$$

Example II—Half-circle S-spring

A flat S-spring consists of two half-circles and carries a compression load P, Fig 14. Calculate the required thickness of stock such that the maximum bending stress will not exceed 30,000 psi when the spring is deflected 0.3 in. Also, determine the resisting force at that deflection. Width of the material is 2 in., $r = 2.5$ in. and $E = 30 \times 10^6$ psi.

Solution:

The deflection factor G from Eq (30), and Eq (38) and (41) can be employed. Here, $\beta = \pi/2$ and $K = 0$ to obtain $G = \pi/4$. Hence Eq (41) becomes

$$Y = \frac{12\pi Pr^3}{bEh^3}$$

The maximum bending stress is found from Eq (38) by substituting $K = 0$ and $\beta = \pi/2$. This gives:

$$S = \frac{6Pr}{bh^2}$$

Thus there are two equations and two unknowns. To solve, rearrange the above equation:

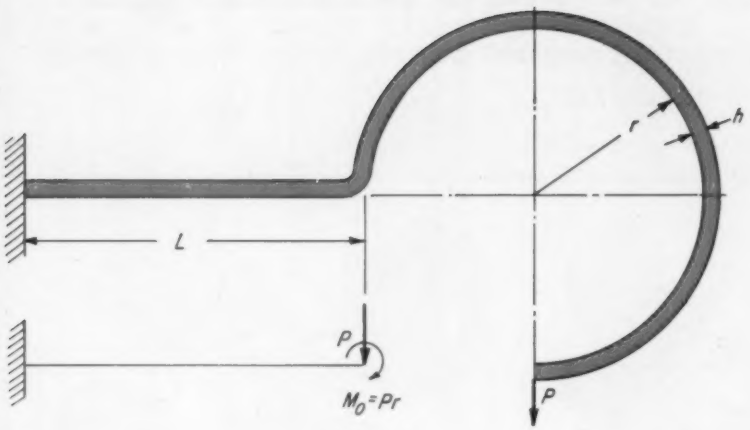
$$P/h^2 = \frac{Sb}{6r}$$

Substituting this expression in the deflection formula gives the required thickness of stock:

$$h = \frac{2\pi r^2 S}{YE}$$

$$h = \frac{2 \times 3.14 \times 6.25 \times 30{,}000}{0.3 \times 30 \times 10^6}$$

$$h = 0.131 \text{ in.}$$



15 Anchor spring

The corresponding compression load can be now found from the stress equation.

$$P = \frac{Sbh^2}{6r} = \frac{30{,}000 \times 2 \times 0.131^2}{6 \times 2.5}$$

$$P = 69 \text{ lb}$$

Example III—Anchor spring

The anchor-type steel spring, Fig 15, carries a load P at its free end. Calculate the downward displacement of the free end, and the maximum bending stress for the following dimensions:

Mean radius of curvature	$r = 1$ in.
Straight arm	$L = 2$ in.
Width of stock	$b = 0.5$ in.
Thickness of stock	$h = 0.1$ in.
Modulus of elasticity	$E = 30 \times 10^6$ psi
Concentrated load	$P = 15$ lb

Solution:

Deflection of the curved portion alone is given by Eq (4). The straight portion can be considered as a cantilever beam loaded with P and a bending couple $M_o = Pr$, as illustrated. The slope at the end resulting from the couple is $M_oL/EI = PrL/EI$. The deflection resulting from M_o in the line of action of P is then:

$$\frac{PrL}{EI}(L + r)$$

The component deflection because of the cantilever effect alone is $PL^3/3EI$. Hence adding the three components gives:

$$Y = \frac{Pr^3}{EI}\left[\frac{3\pi}{4} + \frac{K^3}{3} + K^2 + K\right]$$

Integration of Castigliano equations, Eq (3) and (24), will lead to the same result. The corresponding formula for the maximum bending stress follows directly from the geometry of the spring.

$$S = \frac{6Pr\,(1 + K)}{bh^2}$$

where $K = L/r = 2$. Substituting the numerical data gives:

$$Y = \frac{15(2.356 + 2.666 + 4 + 2)12}{30 \times 10^6 \times 0.5 \times 10^{-3}}$$

$$= 0.132 \text{ in.}$$

$$S = \frac{6 \times 15 \times 3}{0.5 \times 0.01} = 54{,}000 \text{ psi.}$$

It is assumed that no severe stress raiser is present in this spring at the junction of the curved and straight portions.

For **reprint** of above article, just check 632 on one of the Reader Service cards found in this issue.

Editor's note: For more information on flat springs—dimensioning, design equations, costs and materials—refer to these articles:

Dimensioning

Functional Gaging for Flat Springs, Dec 9 '57, p 76—When attempting to dimension a complex flat spring, why not try the functional gaging method. Along with needed specifications, such as deflection at a prescribed load, the drawing can call for a gage setup that simulates operating conditions after assembly. This avoids tight tolerances, tolerance pile-up, and need for skilled inspectors, and reduces costs.

Design Equations

New Equations for U-springs, Aug 7 '57, p 79—Included are equations and charts for the simple-simple, cantilever-simple, cantilever-cantilever, and double-cantilever types of U-springs. For free reprint, check 621 on one of the Reader Service cards.

How Light a Spring for Absorbing Shock, Feb 1 '60, p 49—You don't even have to know the spring's dimensions—these equations of flat and other types of springs quickly find the lightest type. Dimensions can later be varied at will. Six spring types, including special-shaped flat springs, analyzed.

Cantilever Springs that Roll With the Load, July 7 '60, p 58—Providing a curved support for a flat cantilever triples its energy capacity. Covers seven types, including magazine, back-to-back and hinge springs.

For Spring Action—Which Cantilever Beam is Best?, Feb 17 '58, p 83—Comparison of rectangular, triangular, trapezoidal, tapered and parabolic types.

Designing Flat Springs, Part I, July 17 '61, p 61; Part II, July 31 '61, p 45. Nomographs for eight types of single and laminated leaf springs.

Costs and Materials

Flat Spring Material—Costs and Stress Factors, Oct 14 '57, p 125—chart showing the effect of thickness on costs for steel and non-ferrous alloys.

How to Design Flat Reinforced-Plastic Springs, Nov 9 '59, p 74—Reinforced epoxy laminates are more efficient that steel for many leaf-spring applications. Includes design equations.

Formability of Flat Spring Material, Sep 16 '57, p 125—chart helps choose between annealed and pretempered strip steel and gives data for various hardness ratings.

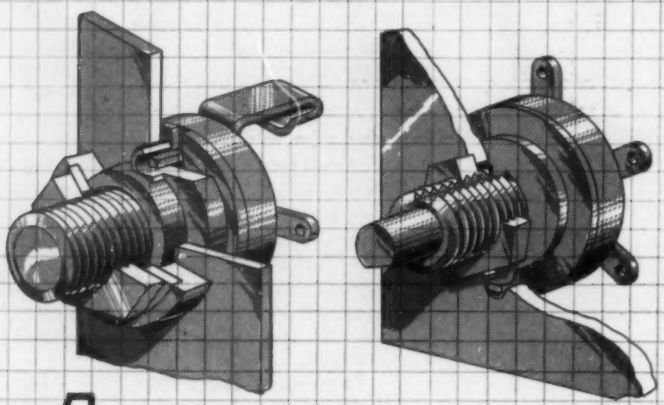
The Best Spring Material for High Temperature, Jan 18 '60, p 44—Super alloy springs of NS-25 stay good as new after several hundred cycles at 1100 and 1400 F. Springs of ordinary stainless are completely deformed after one cycle.

—Nicholas Chironis

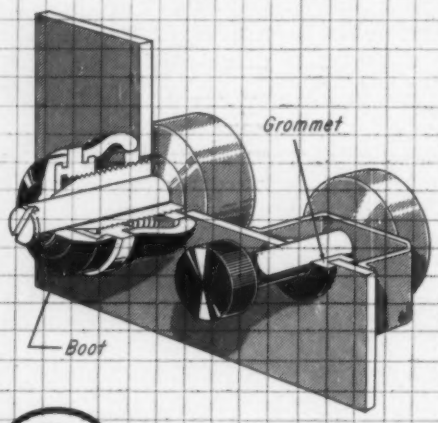
8 Control Mountings

When designing control panels follow this 8-point guide and check for...

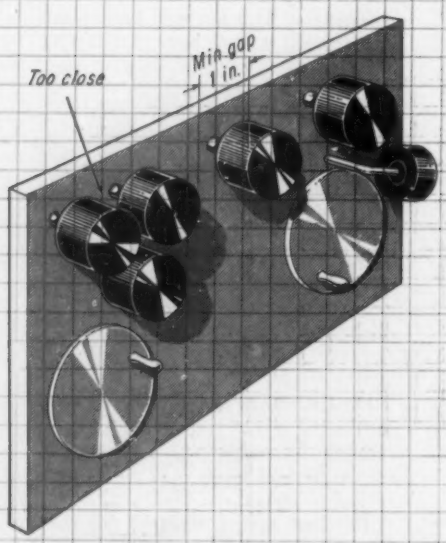
FRANK WILLIAM WOOD JR, president, Advanced Designs Inc, Vienna, Va



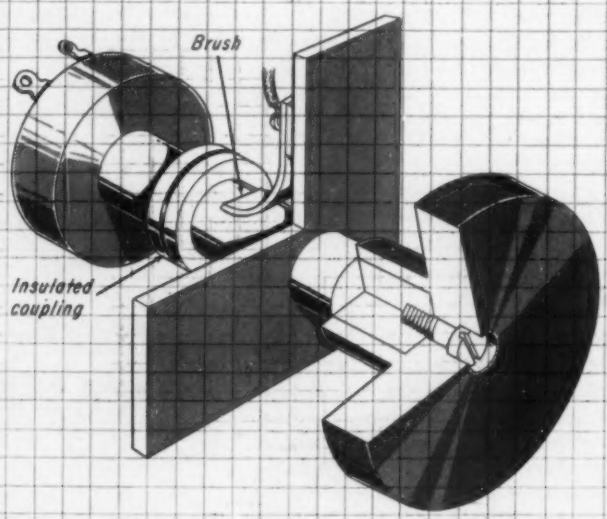
1 ...**LOCKING.** Control will stay fixed in spite of vibration or attempts to force shaft too far. Washer at right has two tabs; one fits in the panel, the other in the control bushing. Left washer has a boss which fits into a cutout in the panel and around a pin projecting from the control body.



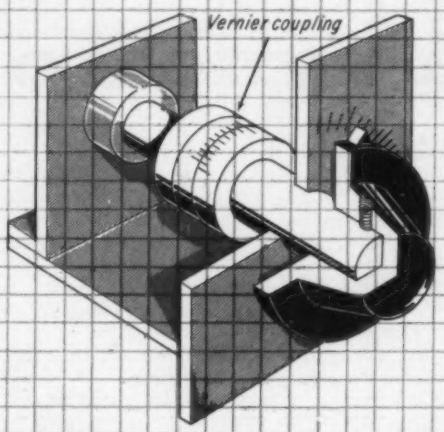
2 ...**SEALING** against dust or water. Boot seals between shaft and bushing and between bushing and panel. With control behind panel rubber grommet seals only one place.

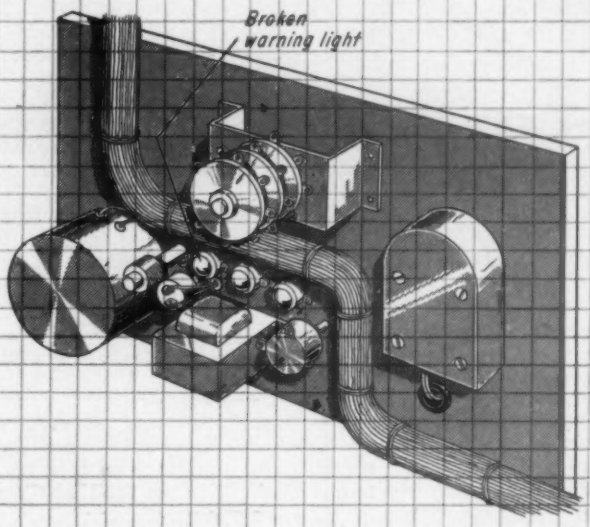


5 ...**HAND-ROOM** at front of the panel. Space knobs at least one inch apart. Extending knob to save space puts it where the operator can bump into it and bend the shaft. Best rule is to keep shaft as short as possible.



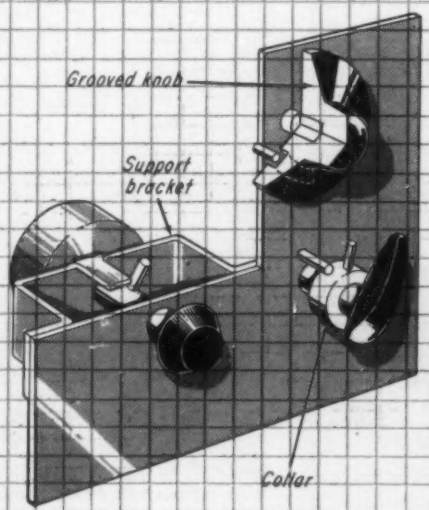
6 ...**"HOT" CONTROL KNOBS.** One approach is to ground them by installing a brush against the shaft. Another solution is to isolate the control by an insulated coupling or a plastic knob having recessed holding screws.

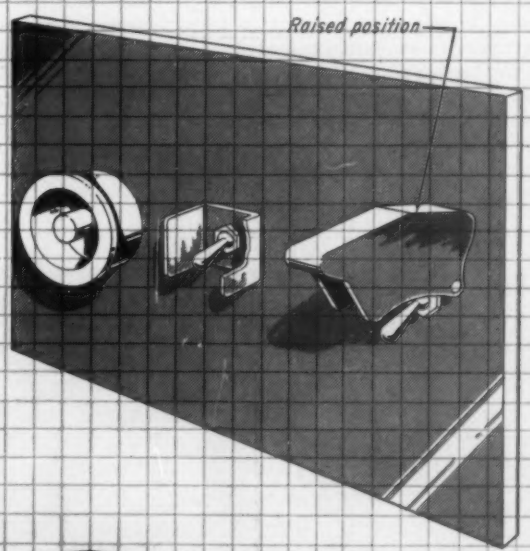




3 . . . **RESETTING** to match controls to panel markings. For crude adjustments a set-screw is enough. Where matching is critical a three-piece vernier coupling permits more accurate calibration.

4 . . . **ACCESSIBILITY** behind the panel. Easy access reduces down time and maintenance costs especially if one man can do most jobs alone. Here, technician can't replace a warning light without dismantling other parts.





7 . . . **LIMIT STOPS** that are strong enough not to bend under heavy-handed use. Otherwise setting will change when stop moves. Collar and grooved knob permit adjustment; tab on bracket doesn't.

8 . . . **GUARDS** to prevent accidental actuation of switches. Bell-shape guard for push-buttons is just finger-size. U-shape guard separates closely spaced toggle switches, and a swinging guard holds down special ones.

How to select a synchro

For remote, precise indication and control in the inch-ounce range.

P J MULVEY, Supervisor of technical proposals, Kearfott Division, General Precision Inc, Clifton, NJ

SYNCHROS transmit torque to remote locations through electrical connections. For a given system, accuracy varies inversely with torque transmitted, resolution is infinite, transmission is elastic, friction can be quite low, but power, at watts level, is required to energize the system.

Basically a synchro is a rotary transformer in which the magnetic coupling varies with shaft position. The rotor carries a two-pole winding and the stator a three-phase winding. When the rotor is energized by line voltage, the voltage in each stator winding depends on its position relative to the rotor. Now connect up another synchro with stators "back to back" and rotors across the same line, and displacement of one rotor produces a torque in the other, tending to keep the rotors in synchronism—almost.

Any load or restraint on the receiver —even its own friction—requires some difference in relative position of transmitter and receiver to produce the torque needed to rotate the receiver. Thus, the "torque gradient" or restoring torque per degree of relative displacement is a primary design characteristic in selecting the size of unit for a given load and specified level of accuracy.

Synchros permit unlimited rotation in either direction, and they retain their synchronous behavior at speeds from standstill to motor speeds. But load inertia—or Wk^2—during acceleration or deceleration retards relative position of the receiver rotor in proportion to load inertia and the acceleration of the transmitter. For high inertia loads retarding effect may become great enough under sudden starts or stops to cause loss of synchronism.

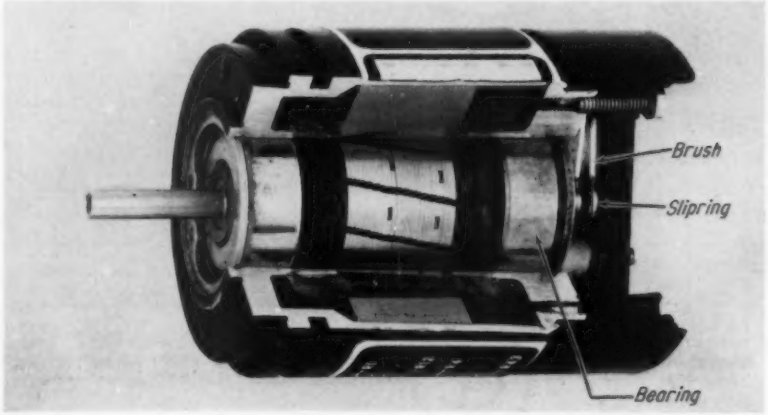
Continuous rotation provides resolution that is infinite—theoretically. However, resolution is limited by characteristics of the magnetic circuit and friction of the receiver and load. Static friction is introduced by bearings and brushes that conduct power to the rotor. The rotor tends to oscillate around the synchronous position; some form of damping, mechanical or electrical, is usually built in to reduce this oscillation.

Power losses are low at synchronous position—determined largely by the no-load heat loss in the windings and eddy-current losses in the laminations. But stator currents increase with relative displacement, and can be damaging if a continuous load or jamming maintains a large displacement. This can become a serious problem with smaller sizes because of limited surface area for radiation of heat.

Selection is a compromise

First step in the selection of a synchro for torque transmission is to find the best compromise between torque gradient, accuracy and size. For small displacements the torque gradient is closely proportional to angle of displacement, and increases with power input. For a given load, accuracy is higher and lag smaller for a higher torque gradient.

Accuracy decreases with an increase in load torque (running torque plus accelerating torque). The combined



Synchro transmitter and receiver are of same construction. Rotor is wound single phase with current supplied from the line through the brushes and slip rings seen at right in cut-away view. Stator winding is three phase, Y-connected, with leads brought out to terminals on the end of the unit. Stator windings are potted. Aluminum housing is supplied with servo mounting grooves. Transmitter and receiver are connected "back to back;" with rotor coils connected across the line, and stator coils connected in parallel. This is a "size 15" unit shown a little larger than actual size.

requirements of load torque and accuracy determine the torque gradient —which can be calculated or determined by test. Torque gradient thus is a sound basis for selecting a specific unit from a supplier's catalog.

Accelerating torque can be calculated from the inertia of the rotor, plus inertia of the load referred to the rotor shaft, and the acceleration required. Procedure is the same as in calculating driving torque for a motor (see combined reprint "Wk² and Motor Selection" listed at end of article). Most catalogs give the rotor inertia for each model along with the torque gradient, max error as measured by a balanced pointer, and power dissipation.

Two receivers from one transmitter

When two or more receivers are driven by one transmitter, the torque gradient supplied by the transmitter is shared equally by the receivers; with decreased torque gradient the receiver error is increased. Where transmitters and receivers are all of similar design with the same torque gradients T_o the torque gradient T_r at each of N parallel-connected receivers is

$$T_r = T_o \frac{2}{1+N}$$

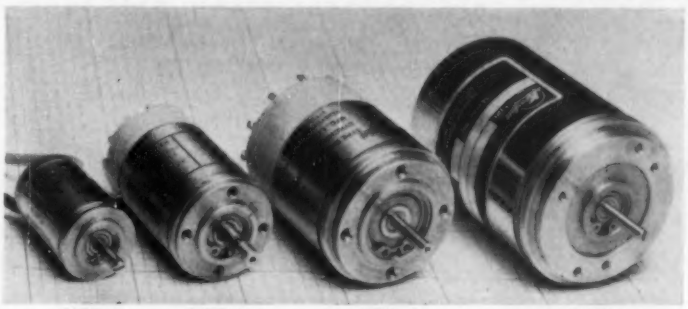
Calculation of error at the receiver must, of course, be based on T_r instead of its rated torque gradient.

Input power to the transmitter will be increased as more receivers are added. The total power therefore must be kept within the rating of the transmitter to avoid excessive temperature rise. If combined loads are close to the rating of the transmitter, it may be necessary to use a transmitter of larger capacity—a problem that should be checked with the supplier.

At synchronism the power losses at transmitter and receiver are approximately the same as the dissipation for either unit with the stator open circuited. Ratings shown in most supplier's catalogs are based on the open-circuit loss. Higher loads can be carried for short intervals if the over-all duty cycle is low, but peak demands on the power source may be much higher than the combined ratings of transmitter and receiver. This will present no problem for units supplied from power lines, but can be an important consideration for synchros supplied by electronic amplifiers or by 400-cycle power sources.

Values of torque gradient and power are usually the same for both transmitter and receiver; max error is less for the transmitter since some torque is needed to position the receiver.

Mounting considerations



SIZE 8 SIZE 11 SIZE 15 SIZE 18

Synchros usually are mounted on end flanges, using a close-tolerance diameter as pilot. Dimensions of the pilot diameters and flanges conform to military specifications and industry standards such as SAE Aeronautical Recommended Practice 461A.

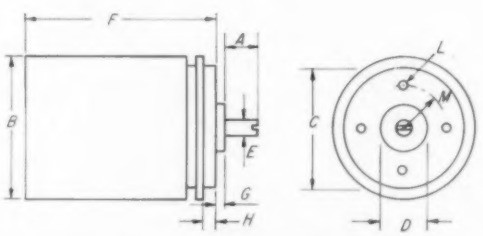
For most applications the synchro is held by three servo mounting clamps engaging a slot in the periphery of the housing. This allows rotation of the body in the mount for zeroing. Many types also provide 3 or 4 tapped holes in the end flange for mounting sectors or arms for adjusting zero position.

Synchros are normally designated by a size number, which is the maximum allowable diameter of the synchro in tenths of an inch. Thus a Size 11 synchro has a maximum allowable diameter of 1.1 in.; the usual maximum diameter is 0.030 to 0.050 in. less. Illustration is 2/3 actual size.

Aside from the basic mounting dimensions, other mechanical characteristics are not yet well standardized and, unfortunately, vary among manufacturers. Shaft size and extensions, shaft runout, mounting diameter concentricities and radial play must be obtained from manufacturer's data. A slot is sometimes cut in the end of the shaft to help in zeroing or test.

Smaller synchros usually have leads for electrical connections; larger sizes normally have terminals. While there is considerable variation in terminal arrangement, the identification is standardized: rotor connections are R1, R2; stator connections S1, S2 and S3.

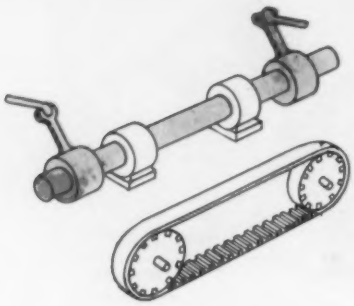
Much helpful and detailed information on definitions, frame dimensions, ratings, test and other specifications are given in the SAE ARP 461A mentioned above. Copies are obtainable at $3 from Society of Automotive Engineers, 485 Lexington Ave, New York 17.

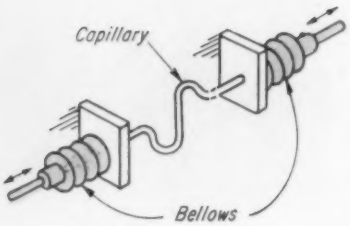


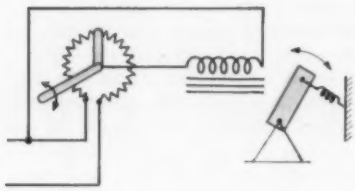
STANDARD MOUNTING DIMENSIONS, SAE ARP 461A

Size	Key	8	11	15	18
Shaft extension	A	7/16	5/16 or 0.555	1/2 or 0.540	0.540
Shaft diameter	E	0.120	0.120 or 0.185	0.120 or 0.185	0.185
Housing diameter	B	0.750	1.062	1.437	1.750
Housing length	F	1.812	1.687 or 1.789	1.98 or 1.93	2.67
Mounting pilot diameter	C		1.000	1.312	1.562
Length of pilot	H		0.062	0.132	0.132
Sector pilot diameter	D	0.500	0.625	0.500 or 0.875	0.938
Pilot extension	G	0.040	0.062	0.040	0.040
No. of holes and size	L		(4) 4–40	(4) 4–40	(4) 4–40
Bolt diameter	M		0.812	0.875 or 1.100	1.250

Systems to transmit torque







MECHANICAL

Mechanical, pressure or electrical devices can actuate position indicators, potentiometers or instrument motors at a distance. Problems presented in selecting the best method and type for an application involve weighing available devices in the light of these conflicting requirements:

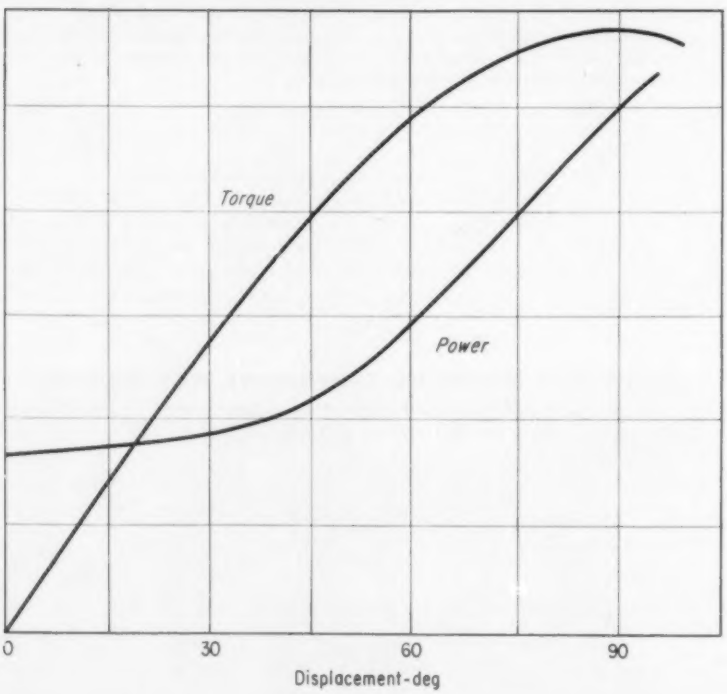
- Length of span between transmitter and receiver.
- Need for mechanical flexibility over the span.
- Travel or range of movement.
- Resolution, linearity, accuracy and stiffness needed for the system.
- Speed of response.
- Effect of friction and backlash.
- Range of power or torque.

Mechanical. Belt and pulleys, chain and sprockets, gearing and flexible shafting all require fixed points for transmitter and receiver, and are limited to short, simple spans. Number of turns is unlimited as is torque capacity, but friction losses may present problems for drives with low power input. Backlash and wear may also pose problems where high accuracy is needed. Fast response and high system stiffness are easily obtained.

PRESSURE

Pressure. Bellows, diaphragms or bourdon elements can be connected to form a simple, accurate low-friction pressure system good for long spans and circuitous paths, but the stiff tubing requires fixed locations for transmitter and receiver. Resolution and accuracy are both influenced by the relatively low power level available and low stiffness of the system. Leakage is a hazard; travel is limited.

ELECTROMAGNET



Torque transmitted and power loss increase with difference in angular displacement between transmitter and receiver rotors. Continuous ratings are limited to displacement angles of 5 to 10 deg by ability to dissipate internal heat.

Power dissipation is given in watts with stator coils open representing the "no load" condition.

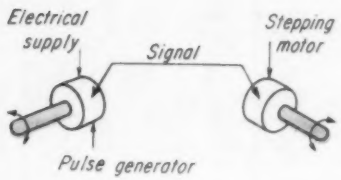
Advantages of 400-cycle power

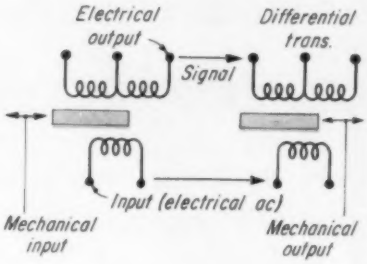
Much of the past experience in design and application of control synchros has come from military and aircraft uses where 400-cycle power is employed for reduction in size and weight. For the same physical dimensions, a synchro unit designed for 400-cycle power will deliver ⅓ to ½ more torque. This is of particular advantage for the smaller sizes.

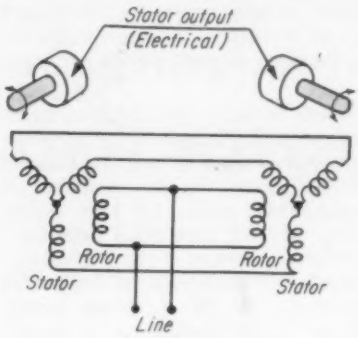
Packaged power supplies and converters for supplying 400-cycle power from 60-cycle or dc supply are currently available, including rotary (small motor-generator sets), electronic amplifiers, or solid-state devices. Close control of wave form is not necessary; torque synchros will operate from a square-wave source with little decrease in accuracy.

Gearing for increased accuracy

A synchro system will deliver higher accuracy if geared up at the transmitter and geared down from the receiver to the load. Friction errors are reduced in direct ratio: a 3:1 step up







STEPPING MOTOR

Electrical. A variety of methods is available using flexible electrical wiring to connect transmitter and receiver, therefore permitting long spans and complex paths. Common systems use rheostats or potentiometers as transmitters and solenoids or indicating instruments as receivers. Sliding contact wear, friction, resolution and limited travel are problems, as are the conflicting requirements for high accuracy and low power level.

Stepping motors, as receivers linked electrically to some form of digital transmitter, provide large torques with high accuracy, but with a problem in resolution. Travel or range is unlimited, and stiffness is high.

DIFFERENTIAL TRANSFORMER

Differential transformers, both linear and rotary, do not require an electrical connection to the moving core or rotor, and have infinite resolution. Power and range are extremely limited if high accuracy is needed, and good linearity is obtained only on small displacements.

Synchros are continuously rotatable in either direction with no limitations in range. Connections are simple and flexible, resolution is infinite and accuracy is high, but power is limited when high accuracy is needed, unless additional amplifier and servomotor components are added.

SYNCHRO

(Coming articles will evaluate types of mechanical drives for control service, devices and systems using pressure, and electrical systems using potentiometers and stepping motors. This article, first in the series, presents the case for synchros. —Ed)

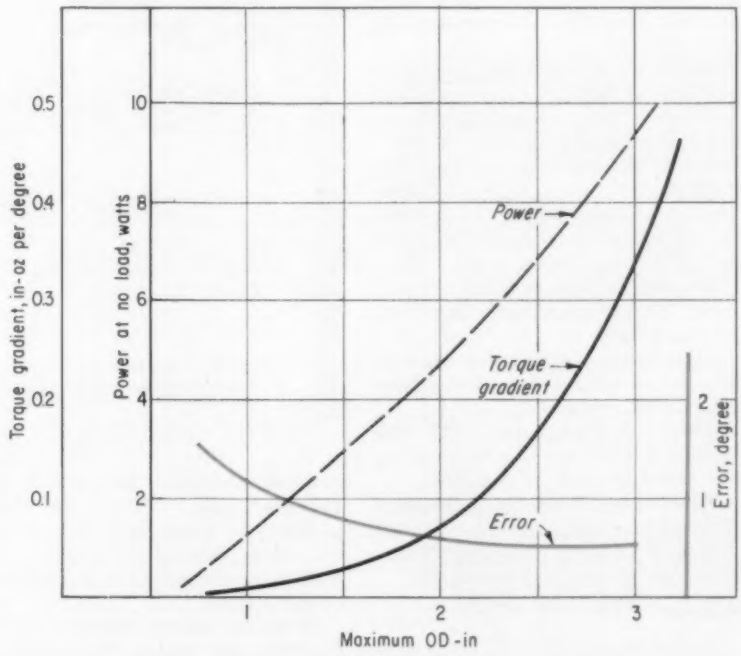
at the transmitter and 3:1 reduction leaving the receiver will cut errors to ⅓. Displacement under torque loads, whether from the load directly or from inertia, are reduced by the square of the ratio: a 3:1 gear drive will reduce the effect of load and acceleration to 1/9.

An inherent disadvantage of a geared drive is that synchronism is lost if the power is interrupted or if a momentary overload exceeds the torque of the system.

Synchro as a control transformer

Where the control problem calls for a large output torque combined with high accuracy, the synchro receiver can be replaced by a synchro control transformer, amplifier and servomotor. In this system the stators are connected in the normal manner, but the receiver rotor is fed to an amplifier, and is also geared to the load. When the transmitter rotor is displaced, voltage set up in the receiver rotor is amplified and fed to the servomotor which drives the load; as rotation of the load brings the receiver rotor to synchronism, the voltage into the amplifier is reduced.

Output torque in this system is not



Accuracy, power and torque gradient required determine the minimum size. These values are representative of standard units but special combinations can be provided to meet specific requirements for torque gradient or accuracy.

limited by the power supplied by the transmitter, but only by the amplifier and servomotor. System accuracy depends on amplifier and gearing; load on the transmitter is determined only by the input required for the amplifier.

Editor's note: For assistance in measuring or calculating Wk^2 for rapid acceleration of load, along with 12 other articles discussing the selection of motors and drives for high inertia loads, see "Wk^2 and Motor Selection," a 64-page combined reprint of articles included in earlier issues. Copies are obtainable for $2 on orders accompanied by remittance sent to Reader Service Dept, Product Engineering, 330 W 42nd St, New York 36.

Design for automatic operation frequently calls for transducers to produce a control signal, and devices to convert the signal to an indication, a force, torque or displacement. Recent articles offering design guidance in these areas include:

Transducers

Angle and Position Measuring Transducers, Aug 21 '61, p 33—40 ways to keep track of mechanical movement and determine position of an object.

How to Select a Flowmeter, May 8 '61, p 35, and **Variable-head Flowmeters,** June 5 '61, p 50—Commercially available types for designed-in use, and procedure for selecting the best type.

Temperature Measuring Transducers, May 22 '61, p 49—Old types and some new ones reviewed and compared in a complete listing.

Which Decision-making Electrical Control, Feb 13 '61, p 37—When to select electromechanical, semiconductor or magnetic systems; practical limitations of each type.

Resistance Transducers, Oct 17 '60, p 76—Discusses linear and rotary potentiometers.

Capacitance Transducers, Nov 7 '60, p 70—Circuit requirements for capacitance probes.

Better Accelerometers Off the Shelf, Sep 5 '60, p 54—Compares six types used in machine controls.

Piezoelectric Transducers Measure Fluctuating Forces, Apr 27 '59, p 61—How they work, and their limitations and advantages in controls.

Receivers

Digital Readouts, Oct 31 '60, p 46—Complete roundup of all types of digital displays, how they work and how to select the right one.

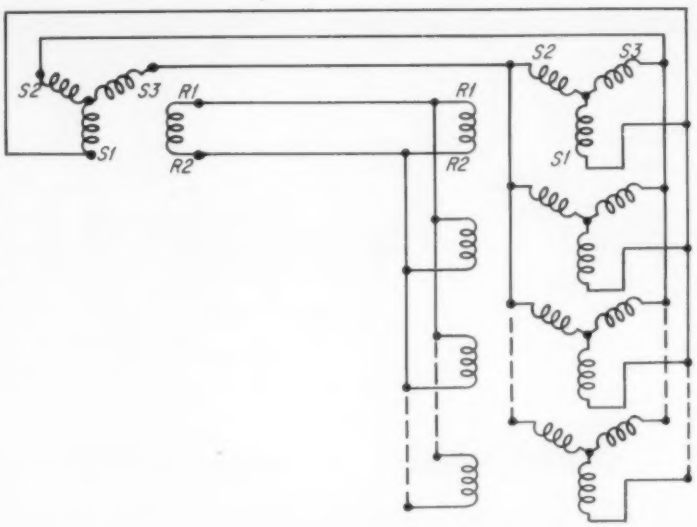
Choosing the Right Mechanical Counter, Apr 17 '61, p 41, and **Mechanical Counters for Speed and Economy,** July 24 '61, p 29—Rules to follow in designing a counter into the system. What is available for over 1000 rpm; advantages and limitations of basic types.

How to Select Electromagnetic Clutches and Brakes for Automatic Control, Dec 19 '60, p 29; **Response Time of DC Clutches and Brakes,** Jan 23 '61, p 41; and **Magnetic Clutches for Continuous Slip,** Aug 28 '61—Series of three articles presenting design data to guide selection of type; how to anticipate the problem of response time, and meet special problems faced under continuous slip.

Which Instrument Motor for the Job, Mar 27 '61, p 43—Factors to consider and two tables that help in selecting the best type.

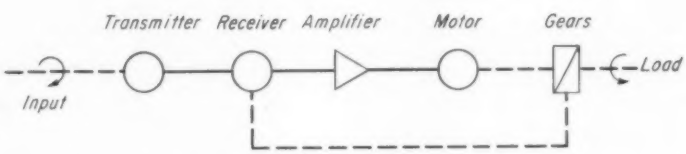
High Force Thermostatic Actuators, July 11 '60, p 74—Comparison of hydrocarbon wax with solid and fluid expansion systems.

—Robert W Carson



For synchro receivers in multiple with one transmitter, torque gradient of transmitter is shared by each receiver; with reduced torque gradient at the receiver, load must be reduced to keep the error at rated value.

Gearing up the synchro to the input with equal gearing down at the receiver reduces error. Power input for the same transmitted torque is reduced by the square of the gear ratio.



Synchro receiver used as a control transformer or resolver with a transformer and servomotor can supply any desired level of output power.

Engine and body varieties highlight

'62 automotive panorama

Car manufacturers try new tack—in-between body sizes and high-performance, economy, cast-iron engines.

THE 1962 parade of cars is bigger than ever. In fact, so big that many will have trouble remembering all the new names—even though they are made by the same big three plus two. General Motors and Ford are both adding "in-between lines" and Chrysler is shrinking its Dart series to match the new sizes.

Outward changes are immediately apparent. Tail fins are gone. False spare-tire holders in trunk lids are gone. The sculptured look is the "new frontier" of auto manufacturers. And the major engineering changes, this year, show up in two places: car bodies and engines.

Bodies. A definite shrinkage is evident in almost every make. The spotlight, of course, is on the new body shells representing the "in-between" car. This group contains the Ford Fairlane, Chevy II, Dodge Dart, and Mercury Meteor.

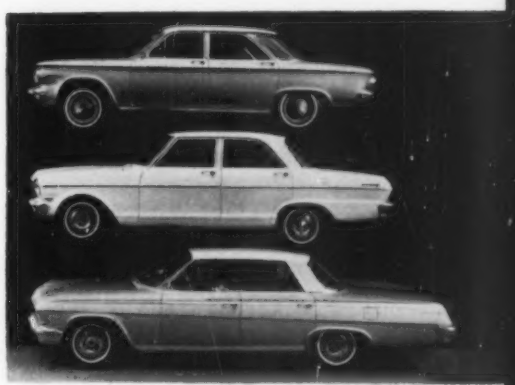
Chevy II is a Falcon-size car, an item needed in the Chevrolet line, according to many observers. The Ford Fairlane, on the other hand, is strikingly close to the Ford of a decade ago (see chart). Chrysler products, of which the Dart is representative, have been merely shrunk, fore and aft.

Chevrolet, with its unitized Chevy II series, is a jump ahead of competition because it will make an early offering of 4-door station wagons and a convertible. These and the Fairlane-Meteor grouping from Ford are all new shells, with weight-saving designs learned from the earlier compacts.

The body shells shared by the senior Plymouths and Darts are all-new, completely integrated units that let these models shed 400 lb. A major saving is elimination of front stub frame.

Engines. At no time in automotive history have so many basically different engines been offered. The trend is away from aluminum, back to cast iron; and the new cast-iron engines weigh only slightly more than the aluminum engines and are easier to produce. Precision molds and cores, plus high-temperature, water-cooled melting furnaces, now produce iron castings with walls under 0.190 in. and research in cast-iron and nodular or ductile iron may give even lighter walls and engines in the future.

For example, Ford's new 221-cu.-in.



CHEVROLET'S family. From top to bottom, Corvair 4-door sedan, Chevy II 300 4-door sedan, and Impala 4-door sedan.

FORD'S new entry. Fairlane 4-door sedan.

CHRYSLER'S new one. Dart 4-door sedan.

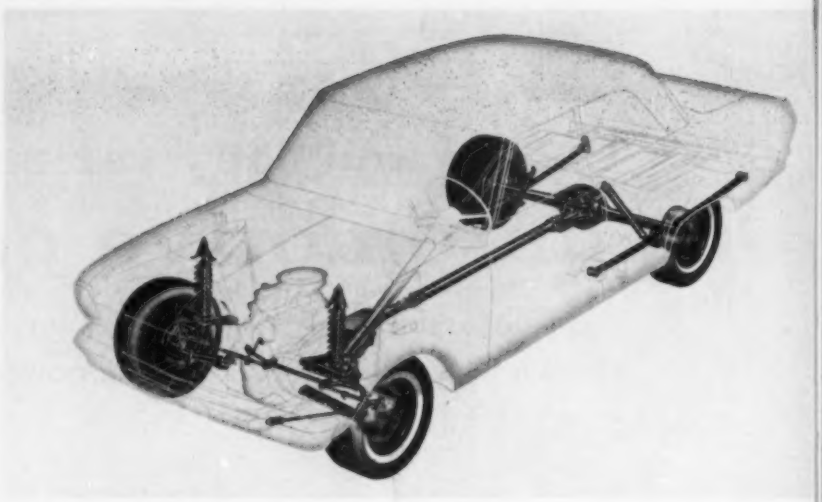
'62 "IN-BETWEEN CARS" ABOUT SIZE OF '49 MODELS

Dimension	'49 Ford	Fairlane	Chevy II	Dart	Meteor
Length, in.	196.8	197.0	183.0	202.0	203.8
Height, in.	63.2	55.5	55.0	53.7	56.1
Width, in.	72.8	71.0	70.8	75.6	71.3
Wheelbase, in.	114.0	115.5	110.0	116.0	116.5
Front leg room, in.	43.3	44.0	43.5	46.0	46.7
Rear leg room, in.	43.4	43.6	38.5	39.1	41.4
Front head room, in.	40.5	38.7	39.0	38.0	39.0
Rear head room, in.	37.8	38.0	38.0	37.8	38.0
Turn to curb dia, ft.	—	39.5	38.4	40.3	39.5
Trunk, cu ft	22.9	29.0	25.5	27.2	31.5
Road clearance, in.	7.5	5.7	6.0	5.0	6.3
Curb weight, lb	3140	2794	2605	3100	2874

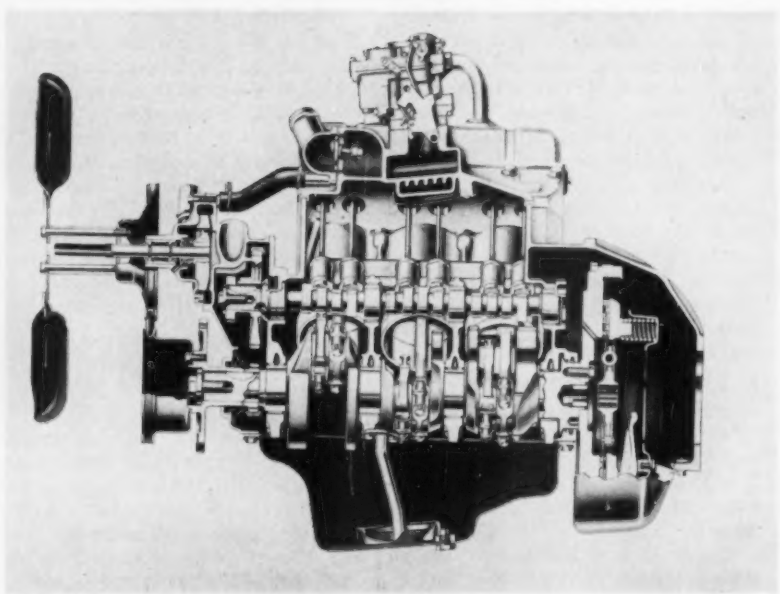
CHEVY II uses a single leaf spring forged from chrome carbon steel rectangular bar stock. The single leaf is ⅝ x 2¼ in. at the center and tapers in thickness to ⅜ in. while spreading to a 2⅝ in. width. Under load the length of the leaf is 62½ in. During fabrication the upper side is shot peened with the spring flexed to put the surface under tension.

The single leaf is insulated at the axle and body connection points by rubber. The center of the axle is sandwiched between heavy rubber pads and rubber bushings are used in the spring eyes. A shackle at the rear of each spring permits the variations in spring length produced by bump and rebound.

The front coil springs are mounted on the upper A-frames and anchored in the sheetmetal wheel housings. The single lower arm is braced by a trailing reaction rod connected to the frame.



BUICK'S compact, the Special 4000 series, has a cast-iron V-6 engine option. The 3.625-in.-bore, 3.2-in.-stroke engine has a displacement of 198 cu in. The engine weighs 362 lb including generator, starter, air cleaner and fan. This weight is claimed to be 140 to 179 lb lighter than current in-line sixes of comparable power output. The new engine produces 135 hp at 4600 rpm and 205 ft-lb torque at 2400 rpm with an 8.8:1 compression ratio. Cast-iron cylinder block has a die-cast accessory drive package bolted to its front end. This section contains the oil pump, distributor, camshaft and fuel pump drives. A sheave on the nose of the crankshaft drives the generator, fan and centrifugal water pump.



V-8 has more power for less weight and engine wear, and with better fuel economy than the 1932 L-head V-8. Ford's casting process is based partly on precision cores, developed from shell molding. Camshaft, crankshaft, and some other parts are shell molded with phenolic binders and sand. The block, head, intake and outlet manifolds, and some housings are precision cored with urea-resin binders and sand.

Buick's new cast-iron V-6 engine weighs only 362 lb, has a 198-cu-in. displacement and delivers 135 hp. Chevy II cast-iron 4-cylinder engine has a 153-cu.-in. displacement and weighs 360 lb, and the 6-cylinder model weighs 450 lb for 194 cu in. and delivers 120 hp. Compare these with the standard Chevrolet in-line six which weighs 608 lb and produces 135 hp.

Ford will use its Falcon 6-cylinder cast-iron engine to power the new Fairlane and Meteor but will continue to invest in additional tooling for its baby V-8 to offer it as an optional engine in these series. The V-8 weighs 60 lb less than Ford's standard six, but out-performs it.

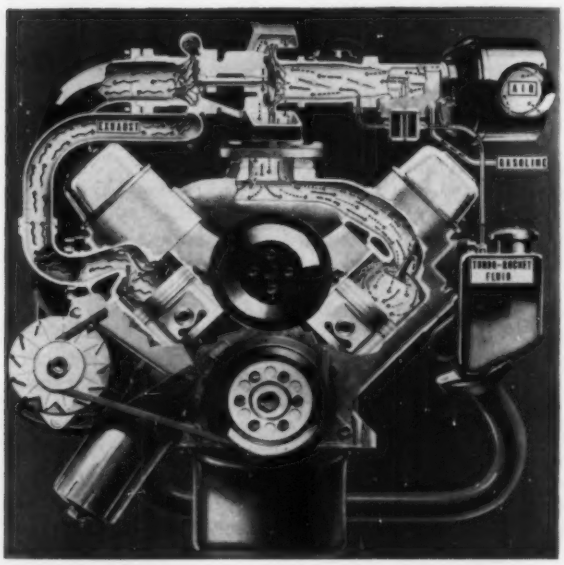
American Motors and General Motors will still offer aluminum engines and there is still plenty of prototype testing and design work going into advanced engine models. Major stumbling block is production costs when compared to the new cast-iron power plants.

GM's semipermanent-molded aluminum V-8 is still offered on the Olds, and as an option on Buick and Tempest. This is a high-performing engine, but production costs are still too high. Corvair's aluminum horizontally opposed, air-cooled six will be back this year.

Rambler's all-aluminum in-line six looked set for this year's model but the resin bond that joined the two halves of the split head failed in its hot water test—after six months exposure. The problem remains unsolved and the Rambler will stay with its present power plant. Doehler-Jarvis is working on a new engine design, planned from the start as a die-cast aluminum block, which may be ready for the 1963 models. Present aluminum engine was originally designed to be made of cast iron.

30 YEARS OF ENGINE IMPROVEMENT

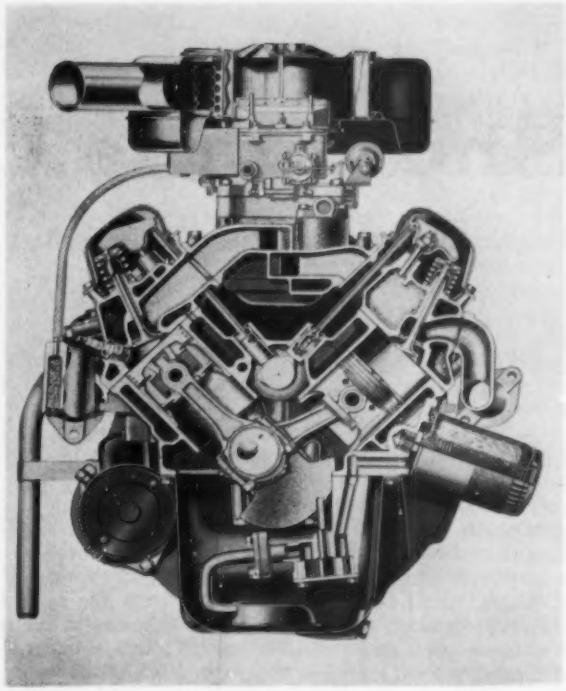
Dimension	'32 V-8	'62 V-8
Displacement, cu in.	221	221
Bore, in.	3.0625	3.50
Stroke, in.	3.75	2.87
Compression ratio	5.5:1	8.7:1
Max bhp at rpm	65 @ 3400	145 @ 4400
Torque, ft-lb at rpm	139 @ 1500	216 @ 2200
Engine weight, lb	530	465
Bhp/cu in.	0.294	0.656
Bhp/lb of weight	0.123	0.312
Main bearings	3	5



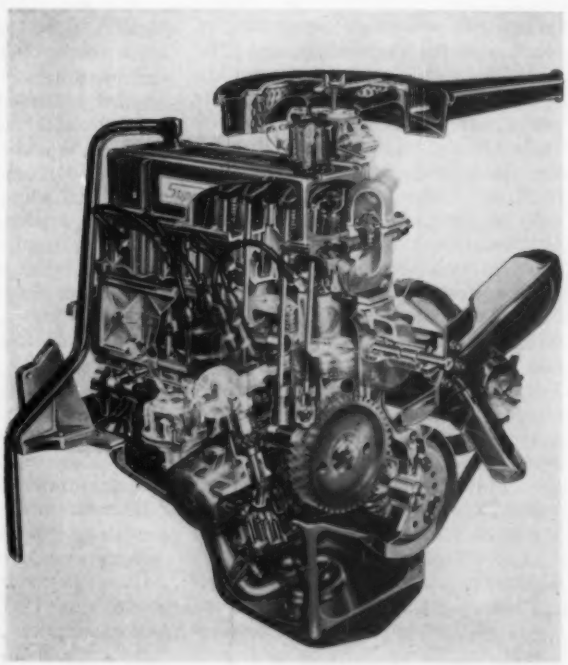
SCHEDULED for production early this winter Oldsmobile's Turbo-Rocket V-8 will use water-alcohol injection, turbo-supercharging and a 10.25:1 compression ratio to produce 1 hp/cu in. displacement, and a power-to-weight ratio of 1.88 lb/hp. The "specially formulated Turbo-Rocket fluid" is an anti-detonant, a necessity with the combination of high compression ratio plus supercharging. The water-alcohol is added to the gas-air mixture and then compressed by the centrifugal blower and delivered under pressure to the intake ports. The engine will be used in a limited production sports car.

CHEVROLET is producing two new engines for the medium size Chevy II series. The 4-cylinder, 153-cu-in. engine weighs 360 lb, has a 3.88 x 3.25 in. bore and stroke, and produces 90 hp. The 6-cylinder 194-cu-in. engine, weighs 450 lb, has a 3.56 x 3.25 in. bore and stroke and produces 120 hp. Compression ratio for both engines is 8.5:1 and hydraulic valve lifters are standard.

Both engines use cast-iron blocks, heads and manifolds with sheetmetal stampings for the oilpan, valve covers, and timing-gear covers. Similarity of the two engines is pronounced and many parts are interchangeable.



FORD Fairlane-Falcon series will offer a new 221-cu-in., lightweight V-8 as an optional power source. The cast iron engine features overhead valves, external counterweight crankshaft balancers, hydraulic valve lifters, and a die-cast aluminum front cover with an integral water pump using a plastic impeller. The stud-mounted rocker arms, which simplify valve lash adjustments, are used to actuate the overhead valves. The cast, malleable-iron arms improve sound deadening and have desirable lubrication retaining properties. Production of the rocker arms require only three operations, casting, coining and drilling an oil hole before final assembly in the engine.



Should the US go metric?

Not long ago, this question was academic; now conversion is a possibility. And engineers are assessing the costs and problems.

A serious movement is afoot within government to consider compulsory shifting of the US to the metric system. A House Subcommittee on Science and Astronautics, under chairmanship of Rep. George P. Miller (D-Calif), recently approved a $500,000 appropriation for a comprehensive three-year study of the costs, financing and returns from shifting to the simpler measurement system.

At present the bill is snagged on the opposition of Rep. H. R. Gross (R-Iowa). Though Gross does not oppose the metric system, he is against spending money for further studies. Despite his opposition, Washington pundits predict the money will be forthcoming this session or next.

Before approving the appropriation, the House subcommittee invited Dr A. V. Astin, Director of the Bureau of Standards, and other specialists in measurement to testify. Dr. Astin's agency had written a report urging creation of the study committee. The report notes that 80% of the world's population, accounting for 60% of its trade, now uses the metric system. Failure of the US to adopt the system, says NBS, may impede our foreign trade. NBS also found that some industries, including chemicals, and pharmaceutics in particular, are already making the shift on their own to a large extent. (The Canadian plant of Parke-Davis completed a shift to metric in 1953, and extended the system to its Detroit plant in 1957. Estimated Detroit cost: $75,000, mostly for scales).

In industry, engineers and plant managers are beginning to consider the problems involved, and report mixed feelings. One engineer more or less sums the formidability of such a change with his comment, "If the US adopts the metric system as its standard for weights and measures, I'm going to quit my job and start manufacturing measuring devices and precision tools. It's the surest way I know of becoming a millionaire overnight."

His vision of a pot of gold in the immense job of converting billions of dollars worth of equipment to metric from the inch/pound system is perhaps optimistic in its timing (the transition, if undertaken, will span an estimated 10 to 30 years), but almost everyone in industry agrees the cost will be high.

The shift would be especially expensive for the metalworking industry. A General Motors source for example says: "If the transition becomes a reality, it will create the largest monster devised. We'd have to start from scratch and recalibrate everything. Cost of such a conversion would be fantastic."

Blueprint blues

And the cost of remaking drawings would also be tremendous. "The ultimate cost to the government as well as to industry to such a change," says another dissenter from the Detroit area, "would stagger the imagination. First, we would have to change all the drawings not only from this point forward, but going back a number of years on anything that is still in use. Take, for example, the M-1 rifle. This is 25 years old. At least engineering-wise, we would have to remake all the drawings, remicrofilm and redistribute them. This, for a simple thing like the rifle, would be a prodigious job, but miniscule by comparison with the B-70, B-58 or B-52 bombers. The cost would be approximately 25 to 30% of the engineering time for the original drawings."

Despite the costs, many engineers cautiously favor a shift to metric. They believe gains from greater simplicity of the system and compatibility with most industry in the rest of the world, and elimination of frequent conversion between science and engineering labs here would earn back dollars spent in conversion.

Typical of this view is the comment of an engineer in a West Coast nuclear manufacturing division of a large company: "We have been watching the system for a long time," he says, "and are glad to see it get this far.

"Our lab could be converted tomorrow, because we already use the metric system there daily. However, it would be a different situation in manufacturing. The single deterrent to switch over is the cost of converting tools. Because our basic drafting data is already in terms of metric system, it wouldn't cost much in that department. There will definitely be a payback in this industry, but we are not sure of its period."

And William M. Allen, president of Boeing says his company recognizes "that American industry will be handicapped and will have increasing difficulty competing in the world market unless a standard measuring system is first adopted on a worldwide basis. The initial expense and general confusion involved will create severe economic impact on all industry. But the sooner the change is made, the easier and less costly it will be."

Many engineering leaders in industry note that the growing complexity of equipment requires that conversion be undertaken immediately or not at all. Some say it's already too late.

The director of engineering for a major tool builder in the midwest wishes we had started to convert 50 years ago. "We'd be sitting back relieved now," he says. But now it would take a long time to be educated and re-educated and to educate all the people who handle tools. In the long run there's probably not enough advantage to offset the cost of such a changeover. Many factors would be affected: we have a tremendous inventory in tooling and we furnish repair parts for old tools."

The manager of engineering for the electronic division of a company making machine-tool controls says his company is "going into more automation and complexity." The situation is already bad, but imagine what it will be like in a few years when a change in the measurement system will mean major redesign in tool control."

He favors conversion but concedes that change-over to the metric system would impose less hardship on the electronics industry than metalworking. His company had less capital invested in production equipment, and in many cases, already uses the metric system. "Frequently when we are concerned with small items we use 'cgs' and for large, 'fps'. Often when consulting catalogs pertaining to borderline sizes, we have to convert when referring to different catalogs.

"**. . . We are at a disadvantage** by not using the system of measurement that most . . . countries use": Dr. A. V. Astin, director, National Bureau of Standards.

Compromise measures

In preference to full metric scale, some companies prefer shifting to the decimal inch. Here again, there is sharp alignment of pro and con feelings. One West Coast engineer says "our department is very much concerned over another proposal often made in conjunction with the metric switchover—to go to an intermediate system, the decimal inch. As far as we are concerned that would only introduce a third system and a second changeover, and would be entirely unnecessary. We would like to see it defeated immediately lest it hamper the basic proposal: a direct switch to metric system."

A midwest machine-tool builder, on the other hand, holds that the compromise proposal of swinging to the decimalized inch "gives many of the advantages of conversion without the severe dislocation. Many manufacturers are doing that," he says, "and they report the upheaval is not nearly so prohibitive. It would not require thread form changes. It eliminates fractions, and makes more sense."

From the same area, an engineering manager for production of aircraft parts agrees that dividing the inch into thousandths, is an adequate compromise. "It'd be even better if our foot was divided into 10's" but feels the compromise serves the purpose without the dislocation and high cost.

The greatest problem now foreseen concerns tolerances. Conversion would call for "sweeping studies to find out how finely to divide the millimeter, the chief of the engineering division of Food Machinery and Chemical in San Jose, Calif predicts. "Engineers would have to decide how much tolerance is needed and where, so they would not carry the decimal point too far in places where less tolerance would do." He notes also that engineers working with the decimal inch tend to think in "lighter" terms. A measurement of $4\frac{7}{16}$ tends to be translated 4.4 in. because of natural tendency to round off figures. Thus, he predicts subtle changes in design and basic concept could be brought about by such a changeover.

Acclaim from abroad

Industrial nations in Europe and Asia, who now use the metric system, feel a shift to metric here is long overdue. They acclaim the proposed study; they hope change will be forthcoming (even hope Kennedy will put his prestige behind it) but hope is realistically tempered with realization of the costs.

In Italy, the pound/inch system is somewhat less mistifying than it is in some other countries such as France where much of the trade in industrial goods is with other metric nations. Italy has acquired most of her industrial equipment from the US and many firms have special offices to translate US blueprints—an accepted but, nevertheless, exasperating addition to costs. Still, many Italian industrial leaders predict further expansion of trade with the US should we go metric. One area, they cite is electric motors. Those made in the US are considered tops, but can't be widely used in Italy.

Officials of the Centre National du Commerce Exterieurs in France predict more trade between the US and France if both were on the metric system. (Even soft items like household rugs present conversion problems, they say.) The French also cite frequent instances of production holdups lasting several months when US designs are licensed to French firms. US companies with branches there also report expense and delay in converting to metric—one electronic company says three draftsmen have been working a month on plans, but haven't gotten the first set completed yet.

But where components are included from the US and England, the French adapt to the inch/pound system. The Caravelle jet, for example, uses both millimeter and inches in its drawings. The airframe, produced in France, is dimensioned in the metric, but jet engine mountings, hydraulic system components and landing gear are dimensioned in inches because these components come from the US or Britain.

Engineers in Germany rank technical cooperation between the continent and English-speaking world very high because the English language is a widely accepted medium of thought communication. But they say communication could be even closer if Britain and the US accept the metric system.

On the military side, there has been considerable interchange of designs for tanks, aircraft and other equipment for the NATO forces—all require an army of converting technicians when they cross metric boundaries. Communications in and out of various NATO headquarters have to contain information in both English and metric. This adds to the time loss and often slows production.

In Britain meanwhile there is a strong body of opinion pressing for adoption of the metric system. Proponents feel they could gain enough additional support to force legislation if the US were to change. In 1960 a survey covering 87% of industry showed 84% of respondents favor Britain's adopting metric weights and measures, but 65% wanted no action unless the Commonwealth and the US follow. Close cross-licensing links between the US and Britain would be a powerful stimulus.

Britain's adherence to the inch/pound has been called one more instance of Anglo-Saxon insularity and egotism, but most observers say it hasn't really hurt trade. They point out that Germany, a metric country, is finding a large market for machinery in the US, an inch/pound country, even though Germany is in direct competition with Britain, another inch/pound country.

Specially designed buoy will

Map Lake Michigan's flow

Engineers want data so they can make better use of our mid-continental water resource.

BRUCE CROSS, Chicago news bureau

AT present relatively little is known about the temperature and current patterns of the Great Lakes. Yet such information is vitally needed to control pollution and make best use of the water resources in this basin.

To overcome the information gap, the Public Health Service is embarking on a long-range, data-gathering program that will cost some $500,000. Key to the program are two types of specially-designed instrument buoys—one to collect deep-water information; the other, information from water up to 100 ft deep.

At first the buoys will blanket the southern end of Lake Michigan; later they will be moved to other parts of the Great Lakes. The data the buoys collect will be used to construct a mathematical model of the lakes. It will predict where currents carry debris or other polluting agents, and how much debris can be safely dumped into the lakes.

The first model of the $25,000 deep-water buoys is being readied for a shake-down dunking this September. It will contain 700 lb of batteries, a punched tape information recorder, and programmer, and a radio transmitter and receiver.

Later models may replace the batteries with a 50-lb fuel cell now being developed by an electrical company. With the cell the buoy will have a self-contained power package to last the winter when heavy ice prevents maintenance by ship.

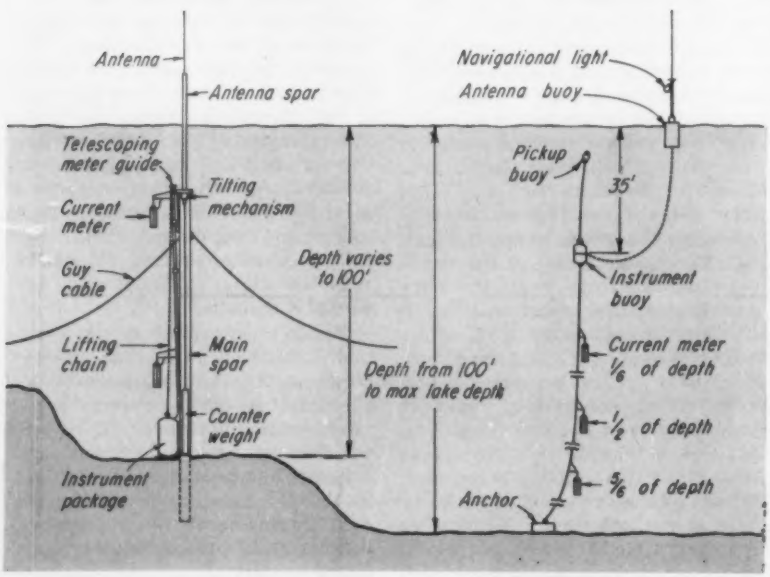
The instrument buoy will be anchored 35 ft below surface by a polypropylene cable. The cable will carry three Savonius current meters, attached at various depths. The Savonius current meters can detect water movement as small as 0.01 fps (about 7 mi per 1000 hr), are capable of measuring current directions even though the instrument case turns in the water. Fixed direction reference is provided by a small magnetic compass in each meter.

The punched tape information recorder in the instrument buoy stores all data obtained by the meters. It has six information channels (two for each meter) and one programming channel. As water currents turn the meters, electrical counters total the number of turns. These turns are punched into the tape each hour and are added so that the hourly total represents the total number of turns since the buoy was anchored.

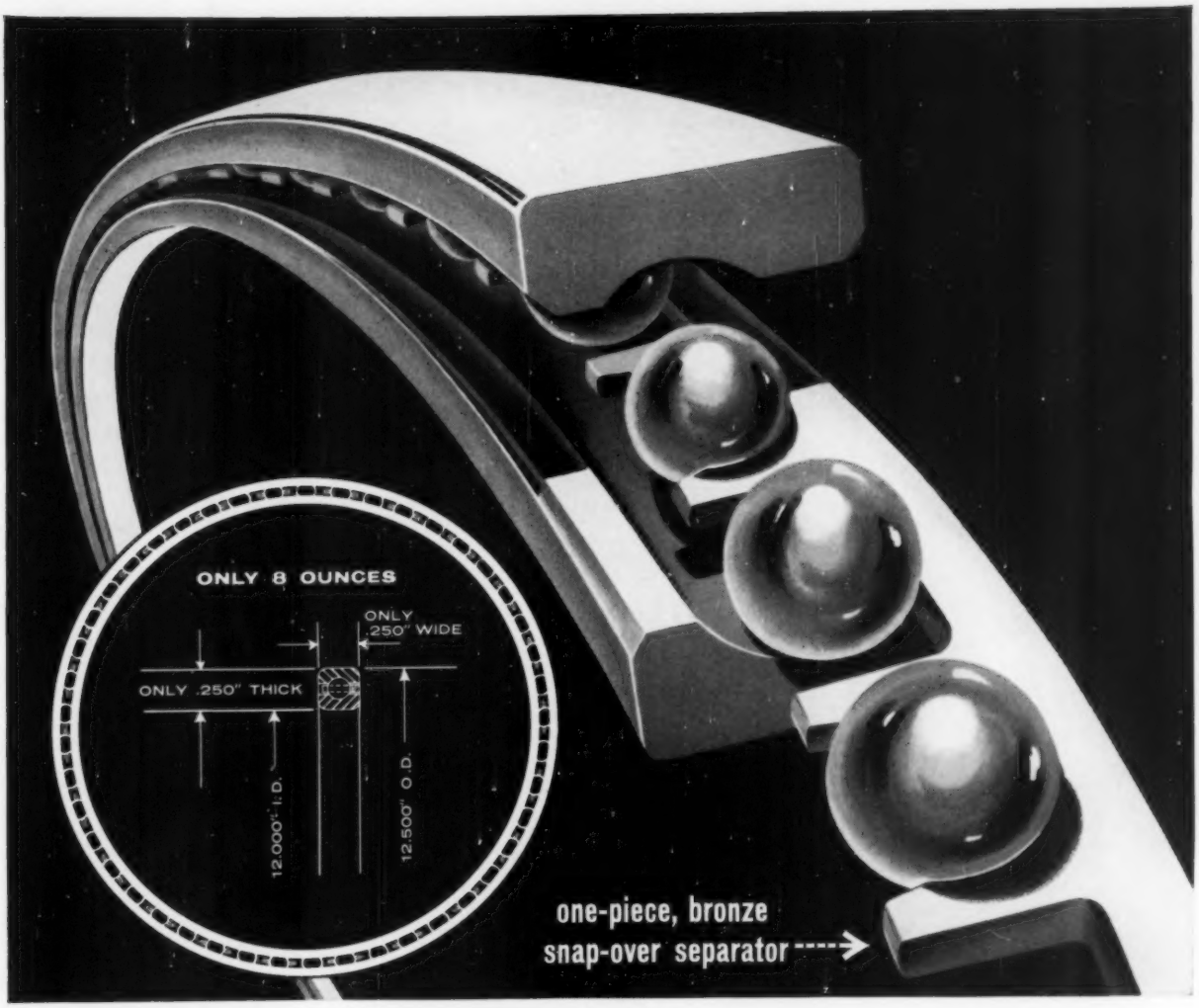
Once an hour, the radio transmitter turns on for a few seconds to broadcast total number of turns and direction of the current. Shore stations pick up the broadcast and convert the information to punched tape for computer analysis. After each burst of data transmission, the buoy's radio receiver is turned on, so shore stations can interrogate it for any specific minute-to-minute data.

The shallow water buoys will lie at lake bottom. They will have two Savonius meters supported by a rigid spar. A special system of weights and flexible couplings will allow the antenna to bend in water, preventing damage which often occurs to rigid structures. The biggest operating problem for both shallow and deep water buoys is expected to be winter ice.

Eventually, weather satellites like Tiros may aid the program by showing what's happening on the water surface while the buoys are recording subsurface events. Photographs of cloud formations above the lakes and wave patterns on the lakes could be correlated with deep temperatures and currents to improve accuracy of the mathematical model.



Both deep and shallow water buoys with modified Savonius current meters will be used to gather information about water currents in the Great Lakes



On the heels of a 500% sales increase...

Kaydon reduces Reali-Slim bearing "off-the-shelf" prices additional 24%

90 sizes—4" to 12" bore—
1/4" to 1" width and cross-section

Due to advantages made possible by greater sales and increased production efficiency, Kaydon now passes along another price reduction on "off-the-shelf" Reali-Slim Type CP Bearings. This new price cut (up to 24%) has been made in addition to reductions up to 76% a year ago.

Save on bearing cross-section and weight—Reali-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

Type "CP" with new one-piece, bronze snap-over separator — Major applications include machine tools; farm, textile and paper machinery; printing presses; pumps and gear boxes; missiles, aircraft and radar; gun turrets and dozens of related installations.

Kaydon bearing engineers are prepared to give you valuable help with technical applications of thin-section bearings.

New "CP" Reali-Slim bearing bulletin includes prices — gives you full details on these 90 sizes of Reali-Slim bearings with Conrad deep-groove, ball-radial construction. Write for your free copy today.

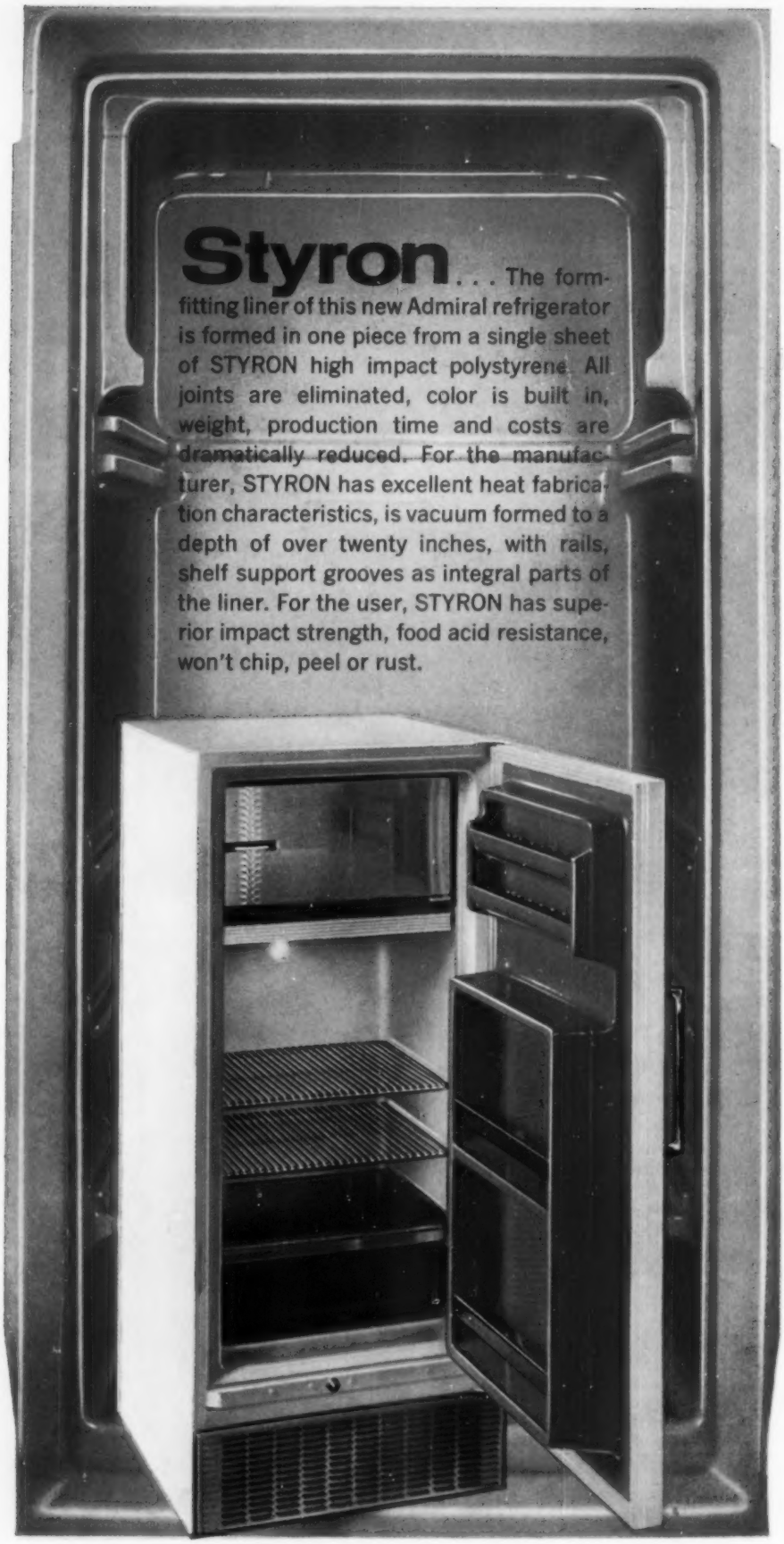
K-593R

20 YEAR KAYDON

THE KAYDON ENGINEERING CORP.

• MUSKEGON, MICHIGAN

All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings


Styron . . . The form-fitting liner of this new Admiral refrigerator is formed in one piece from a single sheet of STYRON high impact polystyrene. All joints are eliminated, color is built in, weight, production time and costs are dramatically reduced. For the manufacturer, STYRON has excellent heat fabrication characteristics, is vacuum formed to a depth of over twenty inches, with rails, shelf support grooves as integral parts of the liner. For the user, STYRON has superior impact strength, food acid resistance, won't chip, peel or rust.

Styron... high impact Dow polystyrene

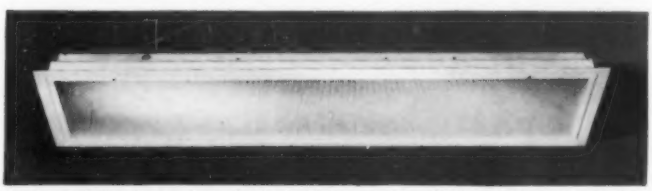
streamlines production in deep-draw, vacuum-forming operation for Admiral

The Styron® high impact polystyrene liner in Admiral Sales Corporation's new nine-cubic-foot apartment-size refrigerator cuts production time by 90% and up-grades quality and product appearance at the same time. This new concept in thermal forming offers designers and fabricators unlimited opportunities for deep-draw, one-piece components.

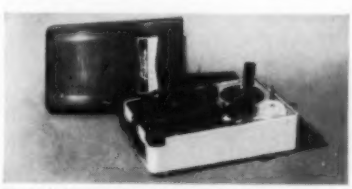
Using a new rotary vacuum-forming machine, and fifteen pounds of high-impact Styron 475B, Admiral deep-forms a one-piece refrigerator liner 46½" high x 23¾" wide x 20$^{12}/_{32}$" deep *in two minutes!* Contrast the half-hour total production time and the reduction in float quantities required in this operation with the five hours' total production time and twenty-two pounds of material required to fabricate the previously used liner.

The finished design: a smooth, food acid resistant liner with built-in color that won't crack, chip, or rust . . . with no joints . . . and with more efficient insulating qualities. Formed into the liner are the crisper rail, two shelf supports, grooves, a two-position freezer drawer slide rail, and four bosses for mounting the evaporator.

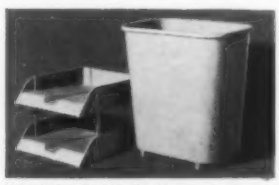
The unusual size of Admiral's one-piece vacuum-forming operation opens the door to deep-drawn designs of even larger and more complex shapes. May we add our experience to yours to help solve a design problem? Drop us a line in Midland, Attention: Plastics Sales Department 1721DZ10-2.



Light stabilized panel, extruded of Styron Verelite®, enables this K-S-H lighting fixture to provide a low brightness controlled light.



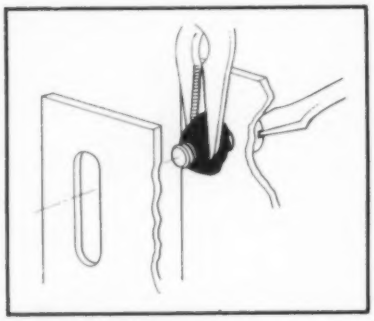
Transistor radio-phono combination by Bell Products is enclosed in case of Styron® for good impact strength and brilliant color styling.



Wastebasket by Rubbermaid uses flexible, chip-resistant, easy-to-clean Dow medium density polyethylene. Letter tray of Styron.

THE DOW CHEMICAL COMPANY Dow Midland, Michigan

NEW COMPONENTS



Quick release fastener . . .
is a wedge or keystone shape all-nylon nut designed so that when it is turned 90° in access slot, ramp-shape ends smoothly ride up on plate face, securely drawing plates together. Quarter-turn engagement is halted by stops molded into central base. Requires no special tools or secondary operations to install, and because fastener is essentially a self-locking nut, tension between plates can be adjusted at any time by tightening or lossening screw. For disengagement, fastener is rotated back 90° to its entry position. Hole molded through center of fastener is unthreaded and has an ID smaller than either a coarse or fine-threaded screw for a specific size. Clamping strength of plastic locking base is said to exceed comparable steel fasteners. Can be used on curved surfaces with radius in excess of 4 in. Available in #6, 8 and 10 sizes, with former two accommodating sheet thicknesses from 0.050 in. up and latter from 0.060 in. up. Grip range is determined by length of screw selected. Prices include: #6, $7.60 per 100; #8, $8.20 per 100; and #10, $8.80 per 100. **Elastic Stop Nut Corp of America, 2330 Vauxhall Rd, Union, NJ.**

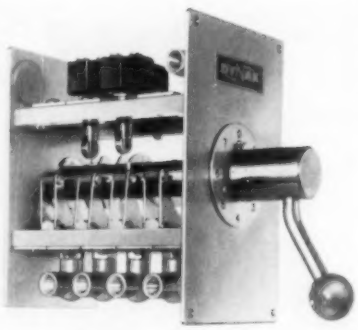
Circle 300 on Reader Service Card

Solid state time delay . . .
is suitable for use from several sec to 15 min. Has wide applications as sequencer, time delay relay and automatic cycling switch. Standard operating voltage is 18 to 28 v dc. **Crane Electronics Co, 4345 Hollister Ave, Santa Barbara, Calif.**

Circle 301 on Reader Service Card

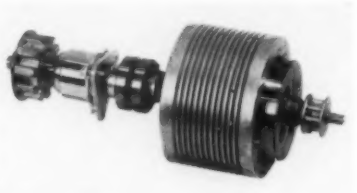
Proximity limit switch . . .
has hermetically sealed contacts of the reed switch type combined with a magnetic assembly encapsulated in an epoxy compound. Actuated without physical contact. When an object of magnetic material is brought within sensing range of switch, a change in flux pattern within switch causes contacts to either open or close. When magnetic material is removed from sensing area, flux pattern within switch reverts to its original state causing contacts to open (normally open switch) or close (normally closed switch). With sensitivity of ⅛ to ⅜ in., switch is said to have sufficient capacity (50 v-amp resistive) to operate small industrial relays, counters and signal lamps. Can be used for counting cans and other magnetic objects, machine control, alarm, signals, etc. Available with either normally closed or normally open SPST contacts and in three case styles: molded epoxy, sheet aluminum and molded to cover plate of ½-in. conduit fitting. Switch measures 2¾ x 1 x ½ in. Priced from $18 to $22.50, with delivery of small quantities within 1 wk. **Deshautreaux Engineering Co, PO Box 261, Kenner, La.**

Circle 302 on Reader Service Card



Process programmer . . .
is a one-knob controller of multiple, sequential functions. Knob turns a camshaft through 360° and a series of cams acts in predetermined sequence upon pneumatic valves or microswitches that control remote devices. Any combination of valves and switches can be arranged, and more or fewer than eight stations are available on request. Use of six cams allow 256 combinations for each valve or microswitch. Either a valve or a switch can be interchangeably mounted at any station. Unit, suitable for test equipment or for startup or shutdown sequencing, relies on a square camshaft for positive drive. Cam holes form 8-pronged star, enabling cam to fit snugly on shaft in any of eight positions. Star wheel with eight detents 45° apart is said to assure precise location at each of the eight knob positions. Basic assembly with one valve, or switch unit and associated single cam is priced at $89.50. **Dynak Inc, 325 Hollenbeck St, Rochester 21, NY.**

Circle 303 on Reader Service Card



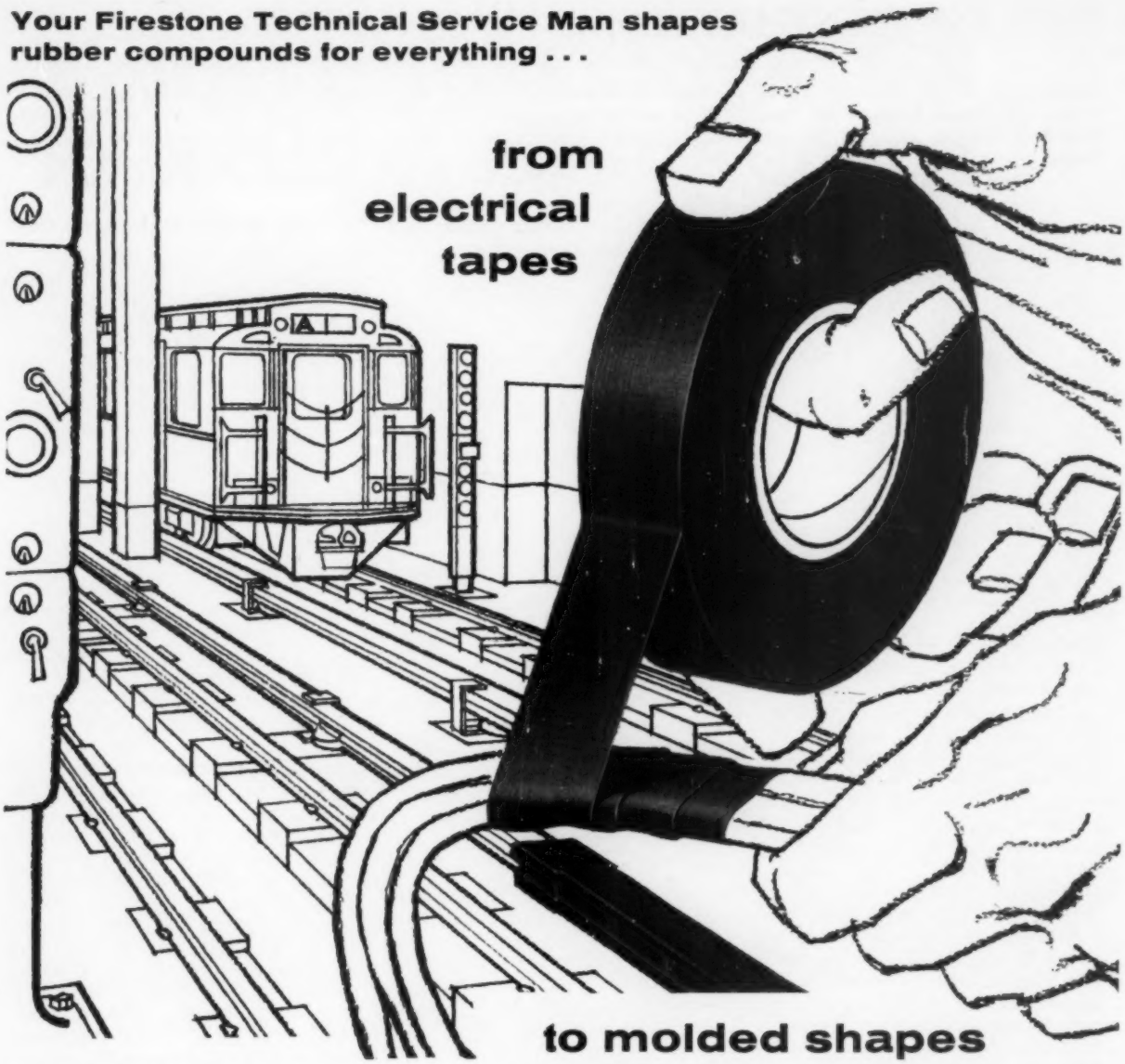
Hysteresis clutch . . .
rated 1/20 hp at 1800 rpm, delivers controllable torque through range of speeds and loads. Reported to be capable of synchronous driving, or continuous slip, with negligble torque variation at any slip differential. Essentially a power-dividing device, unit has output torque proportional to dc control current. There is no mechanical connection between input and output shafts, except shaft support bearing. Measures 2½ in. OD and is suitable for business machines, tape tensioning devices, recorders, servo control systems, etc. **Scanner Corp of America, 30595 W Eight Mill Rd, Livonia, Mich.**

Circle 304 on Reader Service Card

Nylon-insulated switch . . .
needs only ½-in. mounting clearance. Rated 6 amp, 125 v ac, the slide switch consists of a nickel-plated steel case permanently attached to a nylon molded base. Measures 1⅝ x ½ x ½ in., excluding trigger. Terminals are recessed within nylon base in individual barrier channels which lengthen "creepage" paths and prevent accidental contact between terminals. Available circuits include SPST and SPDT. Molded phenolic actuating triggers are available in 11 colors and in heights of 7/32, 11/32 and 15/32 in. Price of SPST unit without optional nylon terminal shield is about 10¢ each in

continued, page 76

Your Firestone Technical Service Man shapes rubber compounds for everything . . .



Need an electrical tape that won't crack or curl in cold? Or molded "third rail" guards to isolate high voltage? Your Firestone Technical Service Man can supply the answers—and he has solutions for thousands of other design problems involving rubber, too. He'll create compounds that defy solvents, oils and acids, stand up to wear and abrasion longer and resist aging. Your Technical Service Man can engineer compounds that combine these and many other qualities, even devise rubber that replaces more expensive materials you may be using in your product now. And he can put Firestone's fabricating facilities to work to carry the job through—in the volume you want, at a price to fit tight budgets. More information? Simply fill out and mail the coupon—without obligation, of course.

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Firestone
Rubber & Latex Products Company
Fall River, Massachusetts

WITHOUT OBLIGATION, WE'D LIKE TO FIND OUT WHAT FIRESTONE'S TECHNICAL SERVICE MAN HAS TO OFFER US.

FMR-FR15(3)

Name and Title

Company

Product Manufactured

Address

City

State

FIRESTONE
RUBBER & LATEX
PRODUCTS CO.
Box 2290, Fall River, Mass.

quantities of 10,000. Delivery within 3 wk. **Electronic Components Div, Stackpole Carbon Co, St Marys, Penna.**

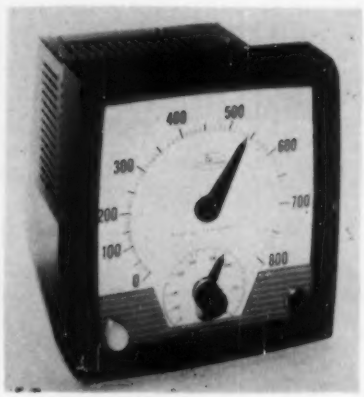
Circle 305 on Reader Service Card

Hydraulic circuit tester . . .
is a 5 x 6 x 8-in. instrument that can pinpoint hydraulic system problems in a matter of minutes. Weighing 20 lb, unit incorporates flow, pressure, temperature gages and a load valve for use in any position on hydraulic equipment. Hydraulic troubles show up as a drop-off in gpm on the flow gage, as working pressure is developed with the load valve. Trouble then is isolated to pump valve or cylinder by taking flow, pressure and temperature readings on various sections of the circuit. Instrument's flow gage has 0 to 10 gpm and 6 to 30 gpm ranges. Pressure gage indicates loads up to 3000 psi and temperature gage records from 20 to 240°. **Schroeder Bros Corp, McKees Rocks, Penna.**

Circle 306 on Reader Service Card

Externally adjustable relief valves
are available in cartridge construction or with integral bodies in either of two pressure ranges—30 to 200 psi and 3000 to 4500 psi. Latter reseat 90% of crack pressure. Cartridge valve, which can be installed in a single body or in a multivalve manifold, simplifies circuitry and can be removed without disconnecting lines. Handknobs are provided for setting pressure to meet system requirements. Made of anodized or hard-coated aluminum alloy and passivated stainless steel, valves function in temperatures of from −35 to 275 F. Low pressure model is nominally 5¼ in. long over-all (including handknob), 3 in. high and 2¼ in. wide. High pressure unit measures approx 5⅛ x 2½ x 2 in. **Fluid Regulators Corp, 313 Gillette St, Painesville, Ohio.**

Circle 307 on Reader Service Card



Indicating temperature controllers
with front-panel control settings and servo-controlled indicating dials, use a precision Wheatstone bridge circuit with a choice of four control modes covering complete range of temperature control from on-off through proportional and 3-position operation. Includes fail-safe resistance sensing elements and have temperature ranges from −300 to 2000 F. Available in three indicator types: indicator only; indicator only for multi-point use; and indicator for multi-channel control use. Front access to all elements is possible by unlocking hinged front. Price range is from $185 to $250. **Electronic Processing Corp, 436 Bryant St, San Francisco.**

Circle 308 on Reader Service Card

Limit stop . . .
for use in apparatus requiring a positive mechanical stop at end of a given rotation, measures only ⅞ in. long and permits settings of from 0 to 100 turns. Hardened pins which make radial contact allow for precise stops without binding. Impact speed is 1/5 the input speed. Can be mounted close to motor or high speed end of a gear train where loads are lightest, prolonging unit's life. Includes ball bearings and is constructed throughout with corrosion-resistant materials. **Dynamic Gear Co Inc, Amityville, NY.**

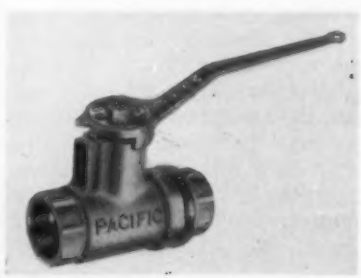
Circle 309 on Reader Service Card

Incandescent lamp . . .
is a rugged, 6-w bulb only ½ in. dia and 1⅛ in. long, including candelabra screw base. Expected to make possible further miniaturization of pilot light assemblies. Two separate 3-w, low-voltage coiled tungsten filaments are connected in series to give lamp max sturdiness. Instead of usual one-filament mount construction, lamp uses two mounts, one to support each filament. Produces 36 lumens and can be used effectively with lenses of all colors in dial light or other indicator applications. Voltage rating is 125, giving bulb an average life of 1500 hr. Priced at 95¢. **General Electric Co, Nela Park, Cleveland 12.**

Circle 310 on Reader Service Card

Multiturn potentiometers . . .
available in both 3- and 10-turn models, are 5 to 600 k-ohm units measuring 1¾ in. dia. Have one-piece molded housings of Durez mineral-filled plastic, said to provide outstanding dimensional stability. Integrally molded, cadmium-plated brass mounting brushings on front lid not only strengthens unitized body but keeps precision-ground, stainless steel shaft permanently aligned. Units have up to 135 tap positions and resolution down to 0.004%. **Duncan Electronics Inc, 2865 Fairview Rd, Costa Mesa, Calif.**

Circle 311 on Reader Service Card

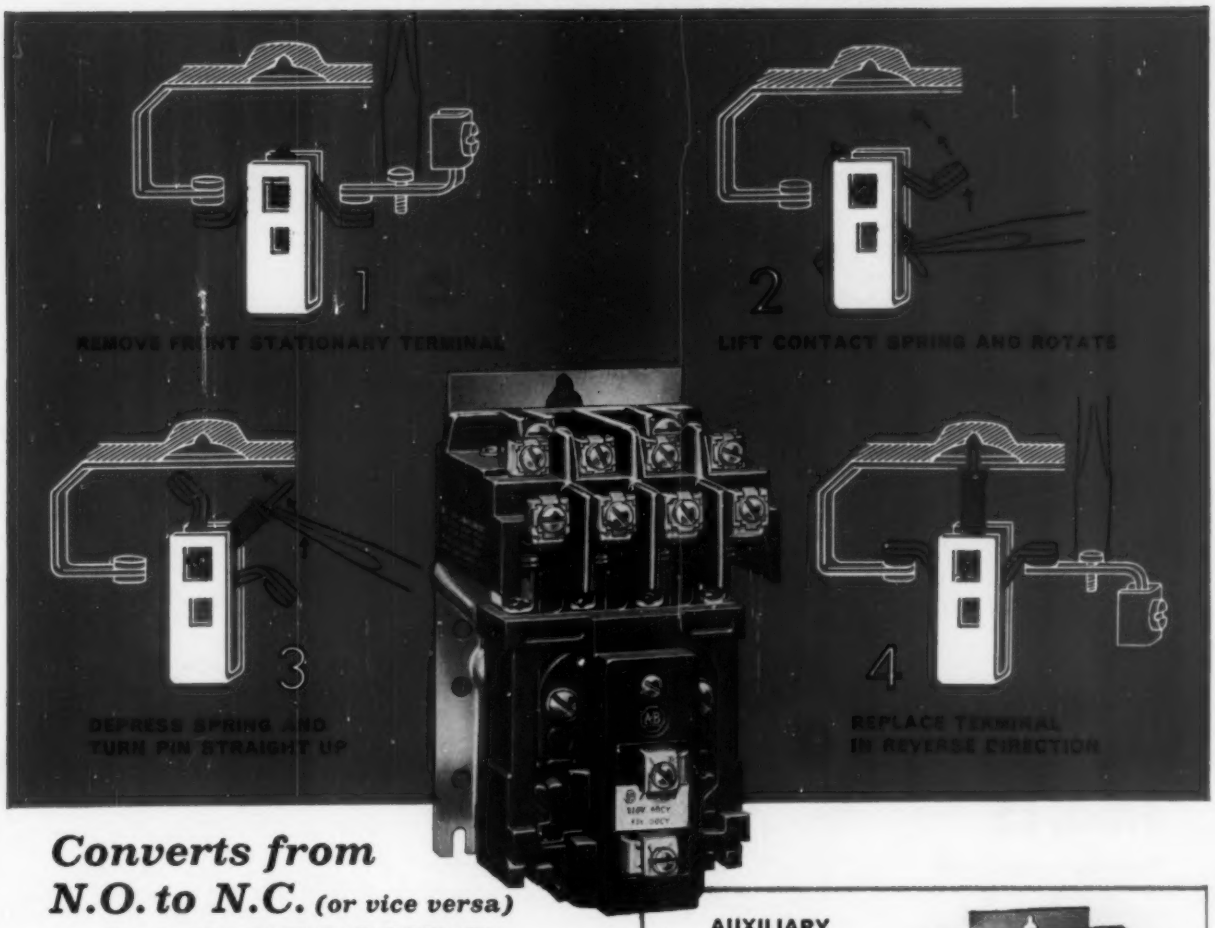


Ball valves . . .
are designed for socket or seal welding in pipe lines. Available in sizes ¼ to 2 in. in carbon or alloy steels for pressures to 1500 psi and temperatures from −40 to 400 F. Ball

continued, page 78

Four simple steps to contact changeover

Total time—not more than 60 seconds

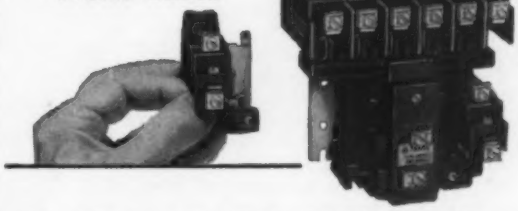


Converts from N.O. to N.C. (or vice versa) in 60 SECONDS!

You'll be truly amazed at the ease of converting the contacts on these Allen-Bradley Bulletin 700 Type BR relays. Using only a screwdriver, as shown above, the contacts can be changed from N.O. to N.C. (or vice versa) in four easy steps—that take only *60 seconds!* Such convenient flexibility is a "natural" for reducing relay inventories.

The Type BR relays are built to provide *many millions* of trouble free operations. With the built-in permanent air gap, magnetic sticking is impossible. And the molded coil is impervious to *all* harmful atmospheres. Of course, the double break, silver contacts *never* need attention. If you use relays, there are money savings for you in the Type BR relay line!

AUXILIARY CONTACTS EASILY ADDED



Type BR relays are available with 2, 3, 4, or 6 poles—but as a valuable bonus, one or two fully rated poles can be added to the base of each relay—even in the field. It's a simple addition that takes only moments.

ALLEN-BRADLEY | *QUALITY MOTOR CONTROL*

Member of NEMA

Allen-Bradley Co., 1329 S. First St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

SELF-CONTAINED J.I.C. POWER UNITS SERVING UNIVERSAL SPIDER TRANSFER MACHINE BUILT BY DRILLUNIT, INC., DETROIT

Six hydraulic hearts

FURNISH MUSCLE FOR 5 TRANSFER OPERATIONS . . . WITHOUT A PALLET

"This is the first time that a spider for a universal joint has been machined in direct transfer of the part itself rather than by pallet transfer," says William Defibaugh, Vice President and Chief Engineer of Drillunit, Inc. The new unit is only half the size of any previous spider transfer machine. Clamping and unclamping the spider are governed by 5 RACINE Model 4FA Pumps, each one a self-contained power unit with its own reservoir. A sixth 4FA unit controls movements which turn, probe and transfer the part from station to station. To complete the hydraulic package, 24 RACINE Model Q Pumps serve the standard self-contained drill units. R. S. Naeyaert, President, adds, "RACINE flexibility in delivering pressurized oil in *variable volume* at *varying pressures* make it the ideal choice."

The HEARTS of this automotive transfer operation are the compact RACINE *Power Units equipped with*

MODEL 4FA
VARIABLE VOLUME
VANE-TYPE PUMPS

RACINE

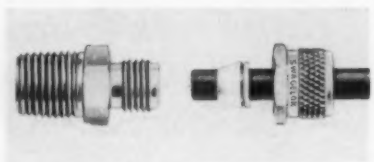
Racine Hydraulics & Machinery, Inc.
RACINE, WISCONSIN
HYDRAULICS DIVISION

seal and stem packing are Teflon. Body joint is seal welded, eliminating body gasket. Stem packing can be adjusted in the field with a hand wrench, and entire stem packing assemly can be disassembled without removing valve from line. **Pacific Valves Inc, 3201 Walnut Ave, Long Beach 7, Calif.**

Circle 312 on Reader Service Card

Insulated stand-off . . .
is self-clinching. Made of Delrin with retainer of steel, stainless steel or aluminum. Aluminum type can be mounted in materials with Rockwell hardness of B-50 or less; steel and stainless steel types, B-70 or less. Has self-locking feature for attaching screw and is available in lengths from ½ to 2 in., thread size 6-32. **Spyraflo Inc, Sub of Penn Engineering & Mfg Corp, Drawer E, Miami 64, Fla.**

Circle 313 on Reader Service Card



Tube fitting . . .
provides leaktight seal on polyethylene tubing of all wall thicknesses without use of inserts. Consists of a brass body with Zytel ferrules and a brass, knurled nut. Wrench pad on nut permits use of a wrench if desired. From stock are sizes for ¼-, and ⅜-in. OD tubing. **Crawford Fitting Co, 884 E 140th St, Cleveland 10.**

Circle 314 on Reader Service Card

Motorless paper tape punch . . .
perforates any 5-, 6-, 7- or 8-hole tape at rates up to 20 characters per sec. Has no motor, clutches and in-

continued, page 80

Shown here is an institutional and dinette chair from the Howell Company, St. Charles, Illinois . . . and its tough, long-wearing contour seat made of MARLEX. The seat is available in a wide choice of colors.

Contour Seat of MARLEX* Improves Styling, Comfort and Utility of Howell Chair

The Howell Company has economically up-graded their popular institutional and dinette chair with a new seat molded from high quality, high density MARLEX plastic. This one material—MARLEX—has replaced previously used seats made of formed steel . . . and plastic sheet over padded wood.

The result is a seat that offers a new combination of comfort and durability . . . won't crack, dent, chip or rust . . . resists staining, water and most chemicals. In addition, MARLEX provides permanent molded-in color and a textured surface that resists soiling . . . never needs painting or recovering, and is easily cleaned.

Furniture components and parts molded or formed from MARLEX improve product performance and increase sales appeal at an economical cost. MARLEX items are lightweight, virtually indestructible . . . resistant to acids, alkalies, greases, fungi, corrosion . . . and possess a wide usable temperature range (−180°F to 250°F). And MARLEX can be molded, thermoformed, extruded . . . items can be welded, machined, fastened, printed upon—never need refinishing.

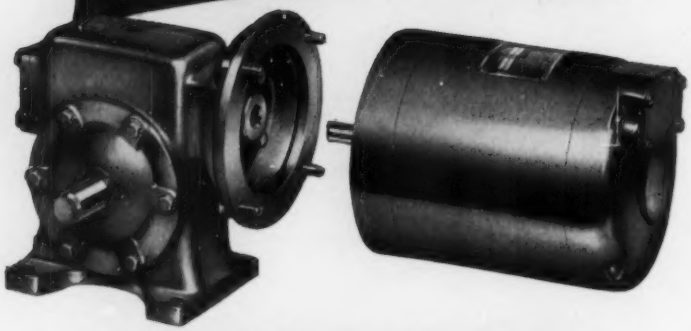
*MARLEX is a trademark for Phillips family of olefin polymers.

For more information, see your plastic fabricator . . . or contact us.

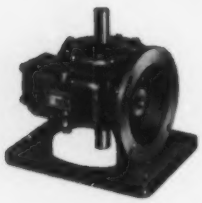
PHILLIPS CHEMICAL COMPANY
Bartlesville, Oklahoma
A subsidiary of Phillips Petroleum Company

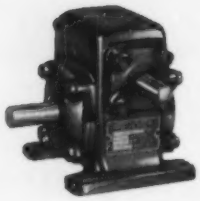
PHILLIPS 66 MARLEX PLASTICS

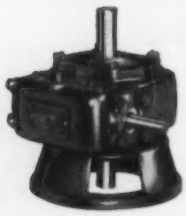
Precision Engineered-
Performance Tested



PERFECTION
Worm Gear
SPEED REDUCERS





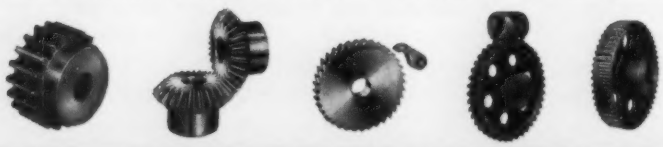


One of our major capabilities is to design, develop and produce speed reducers that will insure maximum performance and economy in your operation. Our experience in the special problems and objectives of power transmission is broad and deep. The men at American Stock Gear having this important capability, use the most advanced analytical engineering facilities to design speed reducers to meet tomorrows needs.

Whatever size or style reducer you need, you'll find the right combination in the complete Perfection line – a line that is precision engineered and performance tested in thousands of different applications.

If you have a reducer problem that you feel is "different", our engineers are ready to advise, design and produce speed reducers to your particular requirements. In the meantime, write for your copy of our Reducer catalog containing illustrations, charts and tables to help you on your next application.

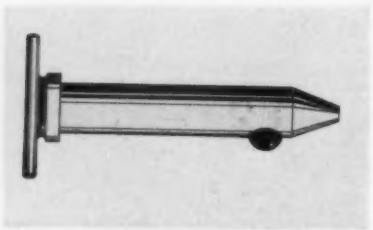
We make a complete line of stock gears. Send for Gear catalog No. 360.



AMERICAN STOCK GEAR DIVISION
PERFECTION GEAR COMPANY, HARVEY, ILLINOIS

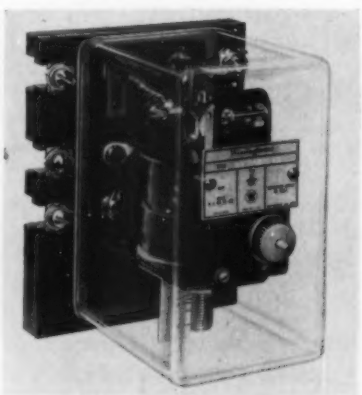
terposers, but is solenoid actuated. Restoring bail assures positive return. In standby operation, no parts are in motion and no current is drawn. Available in three styles: cabinet for bench or desk use; without a back cover for OEM mounting; and with a 19-in. front panel for mounting in a standard relay rack. Basic model is priced at $495, with delivery in 90 days. **Invac Corp, 14 Huron Dr, Natick, Mass.**

Circle 315 on Reader Service Card



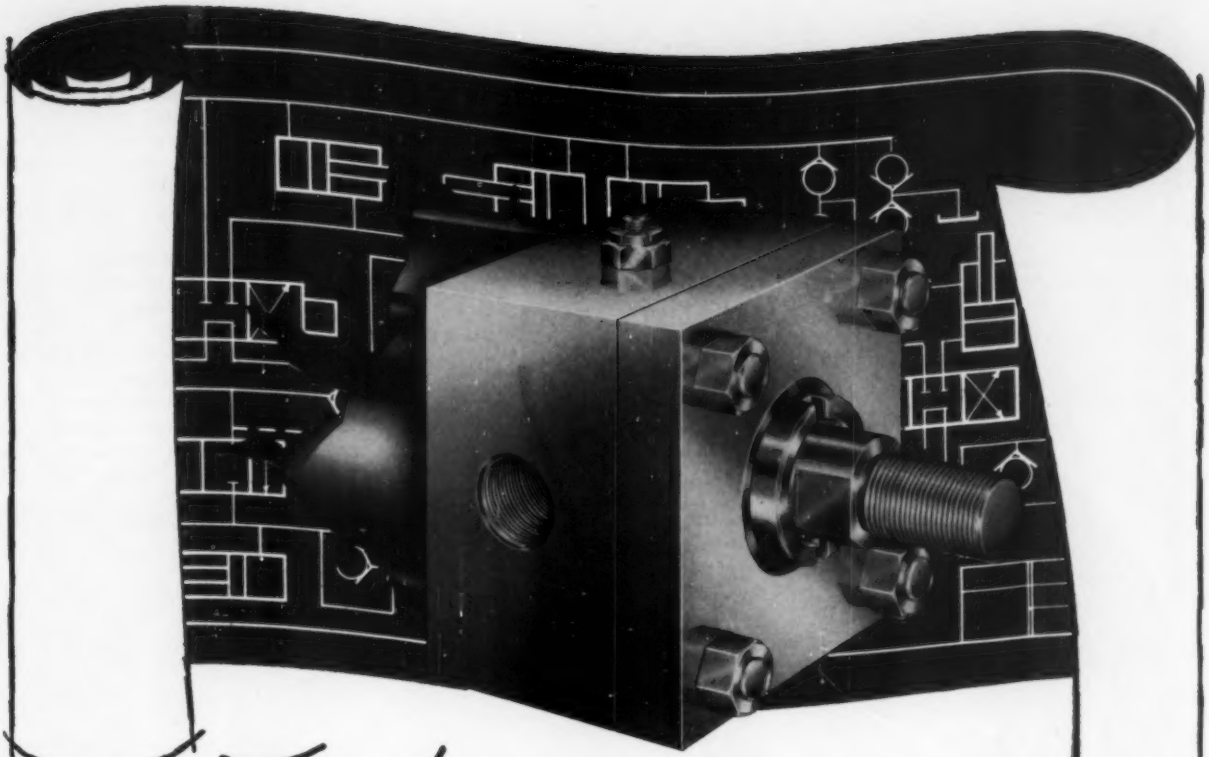
Pointed hitch pin . . .
is for temporary or interchangeable hitching of parts, tools, assemblies, etc. without cotter pins and other locking devices. Pointed and helps to properly align the two holes, and large head allows for quick removal. Furnished in most sizes with one or several locking points positioned where specified in body of pin. Body is of cadmium-plated steel; working parts, stainless steel. **Rein Leitzke, Dept HP, Hustisford, Wis.**

Circle 316 on Reader Service Card



Front connected relays . . .
enclosed in small glass cases, are used as fault detectors to supervise main protective relays or to prevent damage to motors from high current or low voltage under abnormal conditions where time-delay relays would not operate fast enough. Supplied for either dc, or 50- or 60-c ac service

continued, page 82



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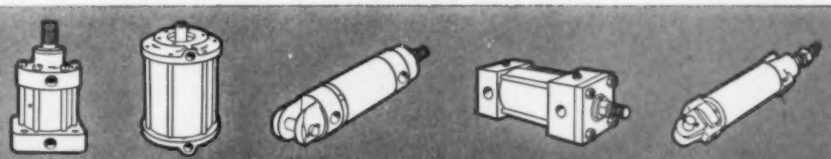

STANDARD HYDRAULIC | STANDARD PNEUMATIC | AIR and HYDRAULIC SPACEMAKER | AIR and HYDRAULIC SQUAIR HEAD | HIGH PRESSURE SPACEMAKER

PLUS complete catalog service

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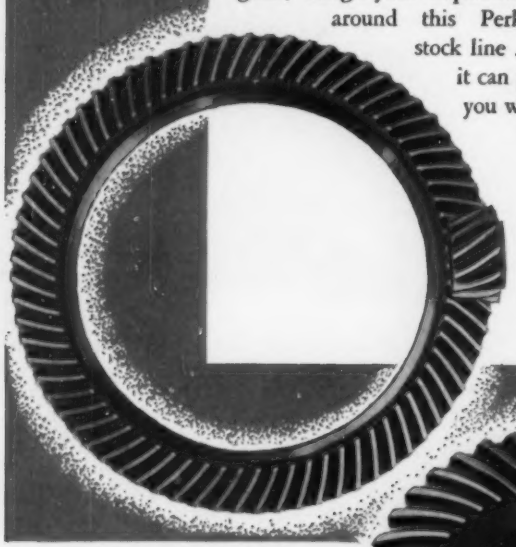
RIVITORS...AIR AND HYDRAULIC CYLINDERS...CUTTERS...CLINCHORS

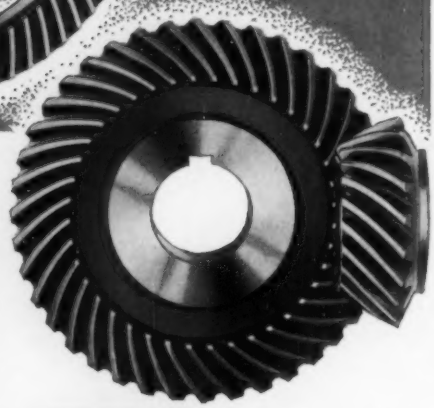
Representation in all major areas, including Canada.

CIRCLE 81 ON READER SERVICE CARD 81

NOW... STOCK SPIRAL BEVEL GEARS TO CUT COSTS

Now for the first time Perkins offers a complete line of stock spiral bevel gears with precision quality to help you get maximum savings in tooling expense and gear cost. When you're planning for spiral bevel gears, design your requirements around this Perkins stock line . . . it can pay you well.





Perkins stock spiral bevel gears have soft bores and may be reworked to a maximum diameter. The gears are matched in pairs and lapped together after hardening for smooth running. In many cases these gears are available in left and right hand drives. This new line of stock gears includes the most commonly used ratios and sizes proportioned according to the Gleason Spiral Bevel Gear System.

AVAILABLE ON REQUEST:

This new folder includes all standard specifications of Perkins complete line of stock spiral bevel gears. Write for folder No. 12.

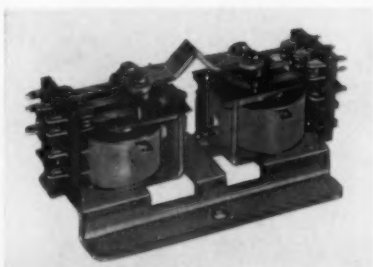
PERKINS
MACHINE AND GEAR CO.
WEST SPRINGFIELD, MASS., U.S.A.

(can be used on dc and 25- to 60-c ac without coil changeover). New design base makes terminals and connections to contacts and coil available from front. Also allows flat mounting. Operating elements are instantaneous plunger types which provide one-cycle operation at two times pickup on ac. Pickup is adjustable over entire range and can be set for specific values of either pickup or dropout. Stationary silver contacts are reversible in the field so that two electrically independent contacts are available. Each contact can be independently set for either normally open or normally closed operation. **Westinghouse Electric Corp, PO Box 2099, Pittsburgh 30.**

Circle 317 on Reader Service Card

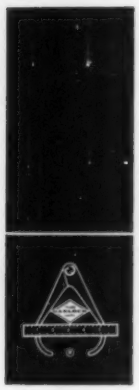
Tiny pneumatic vibrator . . . with a reciprocating piston, has a 0.358-in. piston bore, is 3 in. long and weighs 5 oz. Stroke is 0.094 in. and piston mass, 12.5 gm. Operates on 10-psi line pressure up to 80 psi with a frequency range between 6000 and 18,000 vibrations per min. Recommended operating range is 10 to 20 psi for a low noise level. From stock with single-attaching head at $12.50 each. **Branford Co, Div of Electro-Mechanics Inc, 130 Glen St, New Britain, Conn.**

Circle 318 on Reader Service Card



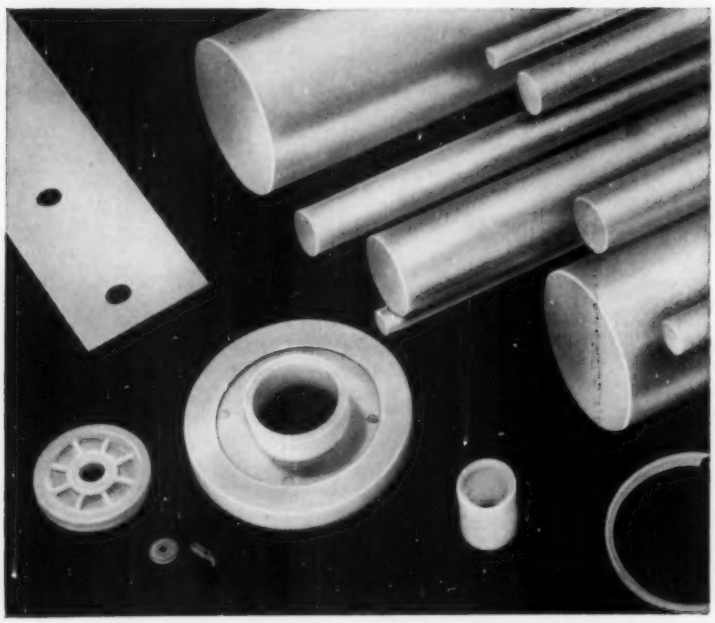
Latching relays . . . include 5- and 10-amp electrical latch, electrical reset units available in a variety of ac and dc coil voltages and with latching mechanisms that have only two moving parts. SPDT, DPDT

continued, page 84



DELRIN

In Design Engineering



For ready cutting and machining, Style 8701 Delrin rod is available in standard diameters 1 ¼" to 3" standard lengths 4 and 8 feet.

NEW GARLOCK DELRIN now ready to help you achieve the extraordinary in product design.

This remarkable new material opens new horizons to you for creativity, product improvement and production economy. Just look at the unique combination of properties that make Garlock Delrin* superior in many ways to metals, as well as to many other widely-used plastics.

- Metal-like strength and rigidity—high dimensional stability and fatigue endurance.
- Resilience comparable to spring steel.
- Resistance to solvents unmatched by most organic compounds.
- Abrasion resistance superior to many metals.
- Excellent electrical properties.
- Low coefficient of friction.
- Odorless, tasteless, non-toxic—pleasant, smooth to the touch.

Best of all, Garlock Delrin retains these properties through a wide range of service conditions—temperature (−40°F to +250°F), humidity, and stress.

Add, too, important Garlock "know how" . . . years of experience in the fabrication of plastics, and unsurpassed molding facilities. Result: a combination that can produce intricate shapes and custom-designed parts never before possible. Garlock design engineers can now work directly with you in creating advanced components . . . parts that replace other materials and do the job better at lower cost.

Look to Garlock as the source for all your plastic needs—Teflon* (TFE and FEP), Nylon, Polychlorotrifluoroethylene (C.T.F.E.), and many other plastic materials. For complete information on what Garlock offers in the way of materials, facilities, and technical assistance, call your local Garlock representative at the nearest of our 26 sales offices and warehouses throughout the U.S. and Canada. Or, write for Catalog AD-177, Garlock Inc., Palmyra, N.Y.

GARLOCK

Canadian Div.: Garlock of Canada Ltd. **Plastics Div.**: United States Gasket Company. **Order from the complete line** of quality Garlock products . . . Packings, Gaskets, Seals, Molded and Extruded Rubber, Plastic Stock and Parts.

*DuPont Trademark

CIRCLE 83 ON READER SERVICE CARD 83

CUSTOM MOLDING
NO JOB TOO LARGE OR TOO SMALL FOR MY COMPANY!
TRADE PUBLICATIONS
I USED THE X Y Z MOLDING COMPANY
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DIRECTORY
WE DO EVERYTHING IN OUR COMPANY FROM THINKING UP YOUR PRODUCT TO SELLING IT!
MY COMPANY CAN SOLVE YOUR PROBLEMS!

Which "CUSTOM" Molder is best for ME?

Molding your present product or new application in plastic or hard rubber is very often the answer to lower costs, better quality and faster deliveries —

BUT — **where** can you find the custom molder that will fill **your** requirements?

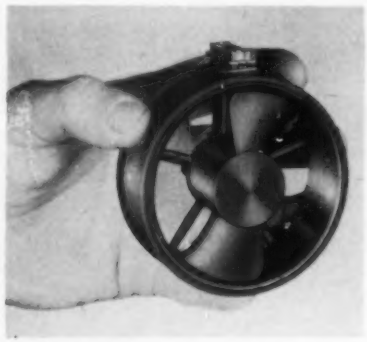
Although much of our competition can cite "blue chip" companies they have served for short periods, few can match the long-time, continuous, repeat business that we at STOKES MOLDED PRODUCTS have enjoyed from our customer list of America's industry leaders.

May we show you our references and actual job samples of why these firms keep coming back for more STOKES service? **Write to Thomas E. Wallis, General Sales Manager, Stokes Molded Products, "U" Street at Webster, Trenton 4, New Jersey.**

P.S. If you want to include a blueprint or drawing with specs, we'll arrive at your office with an estimate you'll really like!

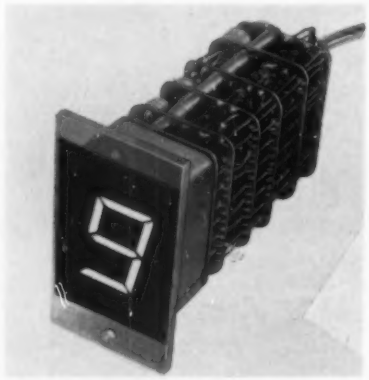
and 3PDT contact arrangements make them adaptable to control and overload applications. Nominal operating power is 2 to 3 w for dc and 3 to 4 v-amp for ac. Life expectancy is 500,000 operations. Temperature range, when specified, is −67 to 185 F. Dimensions of each are 3.5 x 1.59 x 1.62 in.; weight, 5 oz max. **Electronics Div, Elgin National Watch Co, 2435 N Naomi St, Burbank, Calif.**

Circle 319 on Reader Service Card



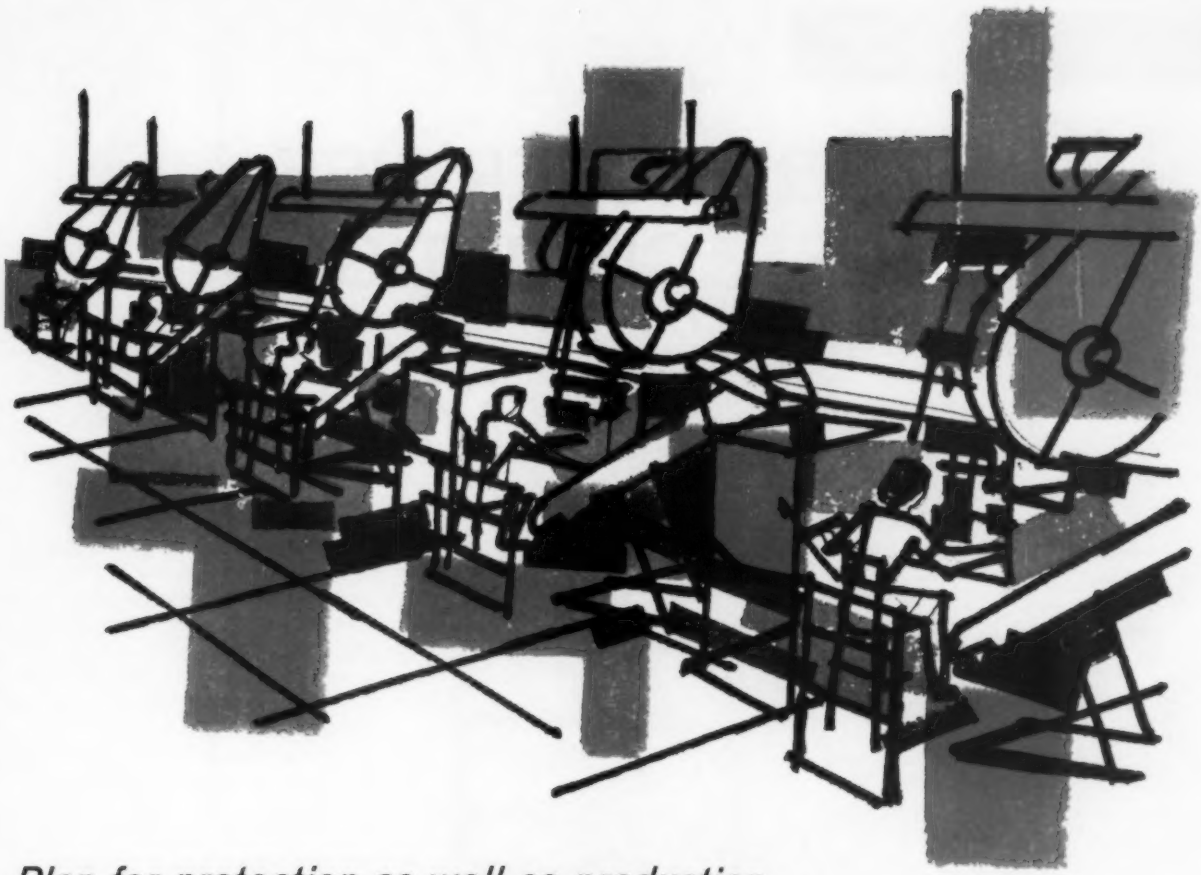
60-cps fan . . .
measures slightly over 3 in. dia, 1½ in. deep and weighs 6½ oz, yet moves 17.5 cfm under free delivery conditions. Power required under free delivery is 0.05 amp at 115 v; speed at that delivery, 3250 rpm. Air flow is reversed by turning end-for-end. Mounting is by means of servo ring. Venturi ring, mounting spider and hub are an integral aluminum casting, anodized and enameled black. Impeller runs on two double-shielded, stainless steel ball bearings. **Rotron Mfg Co Inc, Woodstock, NY.**

Circle 320 on Reader Service Card



Miniature decade counter . . .
operates on only 12 v. Has red, blue, green, amber or gray in-plane display and flexible cable with printed circuit or amphenol connector. Frequency

continued, page 88



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ACCUMITE—small, easily installed system gives positive measured shot of oil or light grease to each bearing.

ACCUMATIC I—simple, single line system for oil or medium weight grease. Wide range of valve capacities.

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ALEMITE OIL-MIST—delivers air-borne oil mist to every bearing to lubricate, cool, shut out dirt and grit.

Only Alemite has all four Centralized Lubrication Systems...one of them is just right for any machine or installation you design.

Modern designs and engineering plans aren't complete without one of the four Alemite Centralized Lubrication systems. Available for *every* industrial application, Alemite Centralized Lubrication protects automatic equipment and installations—keeps performance up-to-date—helps give years of dependable service. When power-driven units are equipped with Alemite Centralized Lubrication all points that need lubrication get it—*automatically and economically.* Operating life is extended. Breakdowns and excessive wear are minimized. Accurately measured amounts of lubricant are applied to prevent waste as well as to reduce material and product spoilage.

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ALEMITE DIVISION
STEWART-WARNER CORPORATION

Dept. CC-101, 1850 Diversey Parkway, Chicago 14, Illinois

In Canada: Stewart-Warner Corporation of Canada, Ltd., Belleville, Ontario

Gasket engineering

THE PROPER USE OF SPECIFICATIONS

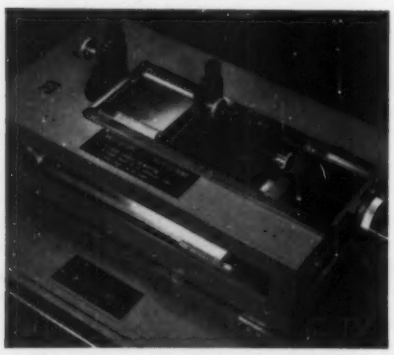
Specification testing is useful as a method of quality control. But specifications alone do not form a sound basis for gasket selection or predicting gasket performance, since performance is determined by the interaction of many factors.

EDISON POWERS
Armstrong Research and Development Center

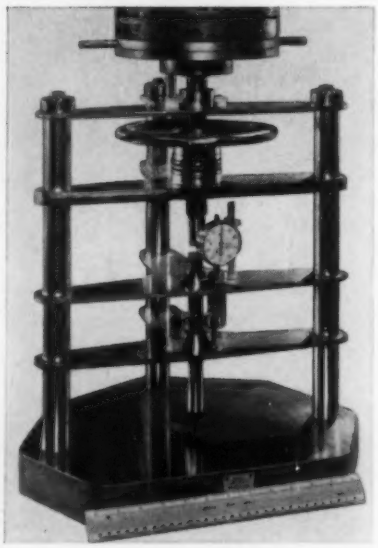
A resilient gasket material that meets all pertinent government and industry specifications may still fail to provide a satisfactory seal in actual service. At the same time, a material that falls short of one particular specification may well be the most suitable for a certain application.

The reason for this is that gasket performance is determined by many factors—such as flange pressure, contained fluid, qualities of the material—in infinite combinations. It is impossible to set up tests which will take all the combinations of these factors into consideration.

As a result, specifications frequently do not give a realistic idea of the gasket's performance. For instance, many gasket specifications have rigid tensile strength requirements. Tensile strength is easily measured. Yet it usually has little bearing on the sealing ability of a material. For all practical purposes a gasket needs only sufficient tensile strength to hold its shape until it goes to work in the flange.



This Armstrong-developed instrument—called a dilatometer—is used to study dimensional changes in gasket materials caused by different conditions of temperature and humidity. It can detect variations as small as half a mil in a 12" sheet.



This device is used by many laboratories to help standardize gasket testing. Developed by Armstrong and recognized by the National Bureau of Standards, it is used to measure indentation and recovery characteristics of resilient gasketing materials.

Tests for resistance to liquids are also unrealistic where uncompressed strips of gasket materials are completely immersed in various fluids. Test results may show intolerable changes in such factors as volume, compressibility, recovery, and elongation. In practice, however, only the edge of the gasket is exposed, and the effect of the fluid may be negligible.

Other tests—ream weight and bursting strength, for example—have been taken from the paper industry. Again they are of little help to gasket users in selecting materials.

Compounding the difficulties of selection by specification is the lack of standardization in test procedures and instruments. In the matter of compressibility alone, there are the variables of sample size and type of pressure foot, and the method and speed of loa application.

Another difficulty with the practice of buying gaskets by specification is the fact that it may delay the discovery and use of new materials that will do the job better. Unless specifications are frequently reviewed, they are likely to be outdated.

Gasketing efficiency can be improved by asking the question, "Will it do the job better?", when you select a material rather than, "Does it meet our specifications?" Once you have selected the proper material, you can establish new specifications and then put specification testing to its proper use—as a means of quality control to make sure that each succeeding shipment of gasket material has the same physical and chemical characteristics.

The Armstrong Gasket Design Manual offers a wealth of research material on gasket design and selection. If you would like help in selecting a gasket material or establishing new specifications or a copy of the manual, write Armstrong Cork Company, Industrial Division, 7110 Irvin Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

new from Warner Electric

easier mounting, greater torque-for-size Electric Clutch

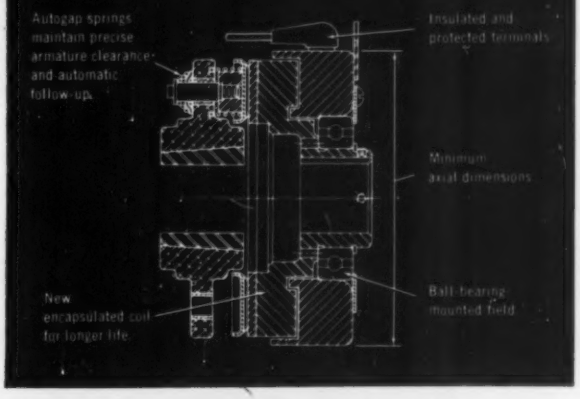
New Warner SF 500 clutch
Static torque rating—50 lb-ft

This new rugged and reliable Warner SF 500 electric clutch combines minimum size with maximum torque—up to 50 lb-ft static. It offers simplified mounting (no collector rings or brushholder) of the ball-bearing-mounted stationary field.

The new encapsulated coil delivers peak reliability, longer life under the severest operating conditions. Minimum axial dimension permits installation of the new SF 500 in smaller space than ever before possible—yet it replaces existing units without reworking or machining.

Improve *your* machine control economically, simply—with the new Warner SF 500 stationary-field clutch. It eliminates complex hydraulic, air, or mechanical linkages—gives you the simplest, most reliable control on the market today. Warner stationary-field electric clutches are now available in torque ratings from 1.5 lb-in. to 1350 lb-ft. Write today for full details.

Check the advanced design features of this new SF 500 clutch


Autogap springs maintain precise armature clearance and automatic follow-up
Insulated and protected terminals
Minimum axial dimensions
Ball-bearing mounted field
New encapsulated coil for longer life

----WARNER ELECTRIC----

Warner Electric Brake & Clutch Co., Dept. PE-10 Beloit, Wisconsin

I'm interested in the new SF 500 clutch. ☐ Send me full specifications. ☐ Have a salesman call.
☐ Send data on complete Warner line of electric brakes and clutches.

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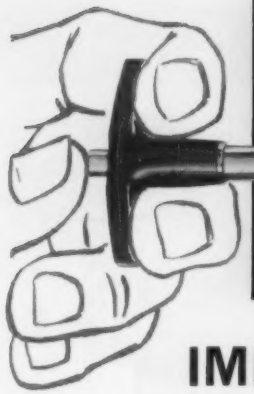

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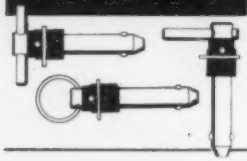
POSITIVE LOCKING • QUICK RELEASE

BALL-LOK PINS

IMMEDIATE DELIVERY

3 HEAD STYLES

DOUBLE ACTING



Double acting, positive locking, quick release Ball-lok pins with push-pull actuating head. Tapered end makes insertion easy. Safety chain is attached to body, **not** to handle, to eliminate accidental release. Especially suitable in difficult applications requiring extra strength, with easy release for quick disassembly. An extended plunger is optional which provides a knock-out feature when necessary. Three different handle styles are available from stock with a wide range of diameters and grip lengths. All Avdel Pins are manufactured to N.A.S. standards.

5 HEAD STYLES

SINGLE ACTING

Avdel single acting pins provide easy insertion with positive Ball-lok safety and instant release when the release button is manually depressed. They cannot be accidentally released.

Ideal for joining portable units requiring fast assembly and disassembly, with positive safety.

Eliminates the use of bolts, washers, cotter keys and rivets.

Five head styles are available to fit into difficult insertion areas, with a wide variety of diameters and grip lengths. These are kept in stock for quick delivery. Manufactured to N.A.S. standards.

AVDEL DETENT

You push it to insert it—pull it to release it. No tools necessary.

The Avdel Detent Pin is an economical, versatile shear pin useable in innumerable applications. The solid body construction, with spring-loaded balls, provides quick insertion and dependable removal. High shear steel insures maximum performance with safety in shear applications.

For units requiring fast, frequent assembly and disassembly, or where emergency release is necessary, Avdel Detents are unexcelled. Avdel Detents are kept in stock in a wide variety of diameters and grip lengths.

SPECIAL PINS

Avdel has engineered over 3000 different types of special pins for unusual applications.

Avdel has produced remote control pins using many types of release such as solenoid, hydraulic, lanyard and others.

This engineering can help you pre-solve your pin problems.

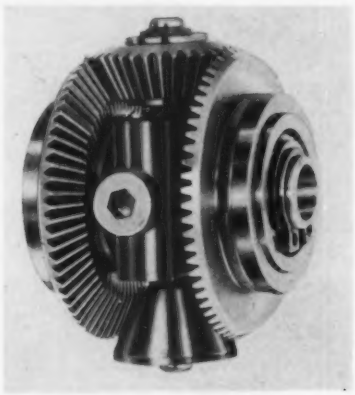
WE INVITE YOUR INQUIRY.

AVDEL INC. 210 So. VICTORY BLVD., BURBANK, CALIF.

TORONTO, CANADA • HERTS, ENGLAND • GENEVA, SWITZERLAND

response is 200 kc; pulse resolution, less than 5 micro-sec. Measures 1⅞ x 2⅛ x 4¼ in. and weighs 6 oz. Priced at $98 each in quantities of 100 and up. Delivery in 3 to 4 wk. **Robotomics Enterprises Inc, 4624 E Garfield, Phoenix 8, Ariz.**

Circle 321 on Reader Service Card



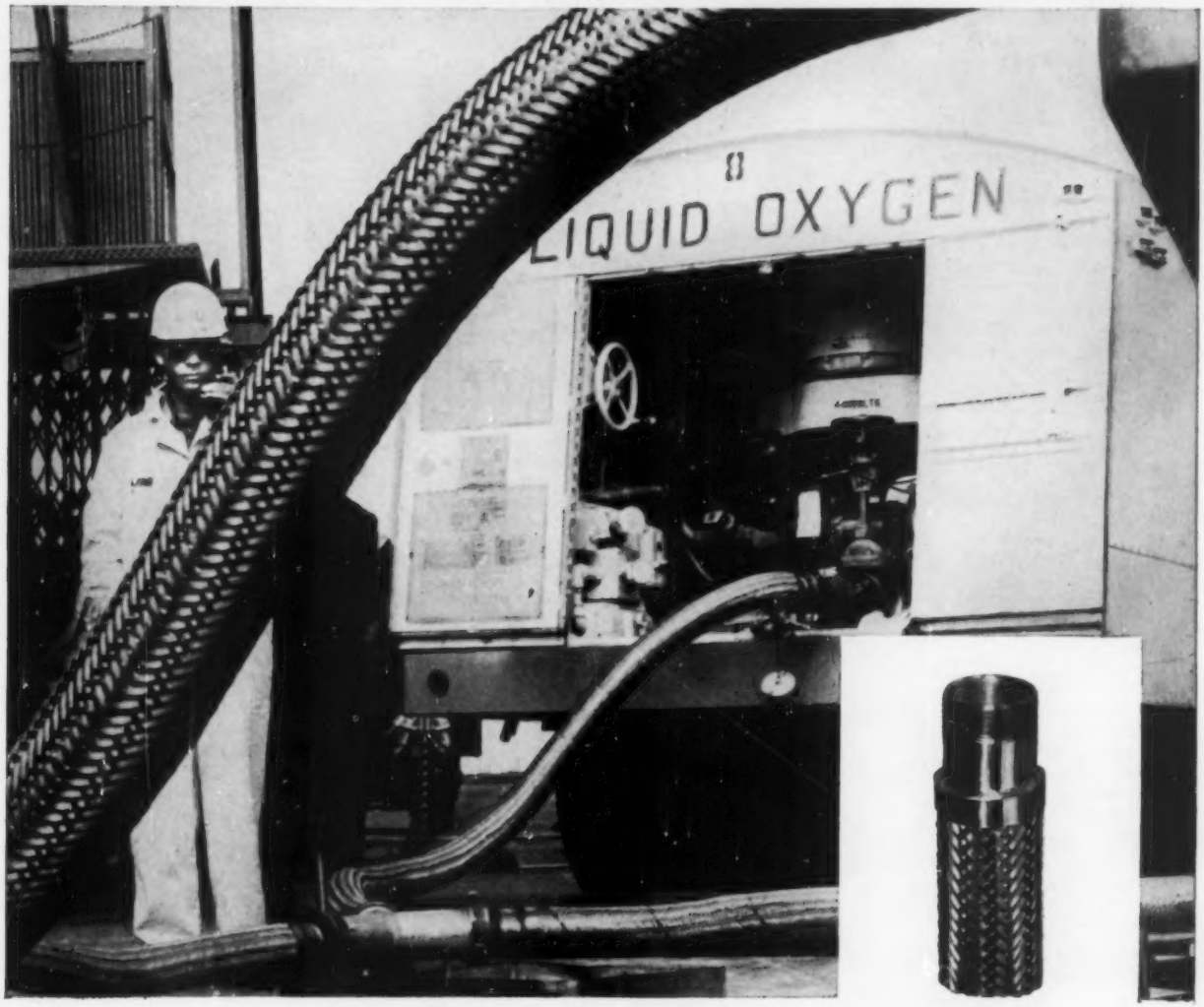
Hollow shaft differentials . . . are for use in computers and control instruments where mounting requirements are restricted. Provide clearance circles down to 1 in. or less. Includes central built-in clamping, backlash of 8 min. or less and breakaway torque of 0.3 oz-in. or less. Construction is of stainless steel except where aluminum spider gears are specified. Each unit has miniature ball bearings conforming to ABEC 7 tolerance requirements. Available with 0.1248-, 0.1873- and 0.2498-in. bores in narrow and standard width (miter) designs. Units are precision balanced and can be supplied with end gears made from flat blanks parallel within 0.0002 in. Pitch and number of teeth for end gears can be selected from wide range. **Instru-Lec Corp, 520 Homestead Ave, Mt Vernon, NY.**

Circle 322 on Reader Service Card

Oil filters . . . provide two-stage filtration of particles larger than 8 to 10 microns. This is achieved by using two layers of alpha cellulose. Outside layer is untreated and offers a pure absorbent surface with a high affinity for dirt, moisture and acid. It filters out contaminants before oil passes through impregnated second layer for fine straining. Units provide full flow filtration at low rates of flow. At high flow rates, increased pressure differential across filter causes a poppet valve to open. This by-pass action

continued, page 97

3½ inch I.D. Anaconda flexible metal hose lines are shown here transferring liquid oxygen to Army missile. Brazed metal hose-to-fitting connections are made with Handy & Harman brazing alloys.



Handy & Harman Brazed Connections Withstand Thermal Shock From Liquid Oxygen . . . Time After Time

It is hard to think of a single more punishing test for a metal joint than the nearly instantaneous plunge from approximately 100° F to –297.4° F experienced by these brazed metal hose connections. Yet they take it time and again – and come back for more.

This is part of an assembly employing Type 321 stainless steel flexible hose made by Anaconda Metal Hose to transfer liquid oxygen to Jupiter missiles at the Redstone Arsenal. Fittings are stainless steel, integrally bonded to the hose by Handy & Harman brazing alloys – EASY-FLO and EASY-FLO 35 with Handy Flux. The reasons for using Handy & Harman brazing alloys here make good fabricating sense no matter what the job. First, they provide strong, integral joints that remain strong, ductile and resistant to vibration and shock even to liquid oxygen temperatures and pressures where many metals become brittle. Secondly, they allowed Anaconda to increase burst pressure limits since there is no annealing of the base metal. In addition, they make it possible for Anaconda to perform joining operations with less equipment and less expense in manpower than would otherwise be necessary.

This is only one example of many applications of Handy & Harman brazing products in cryogenics and other fields of engineering to solve critical bonding problems which achieve fast production and operating economies. There's a good chance they will do the same for you. Call or write for further information on how to apply brazing techniques to solve your fabricating problems.

Our Bulletin 20 contains a wealth of data on silver brazing, its range of applications and techniques for securing best results. Write today for your copy.

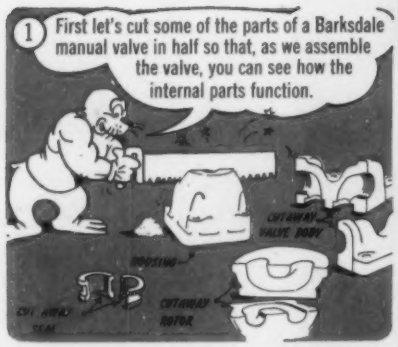
Your No. 1 Source of Supply and Authority on Precious Metal Alloys

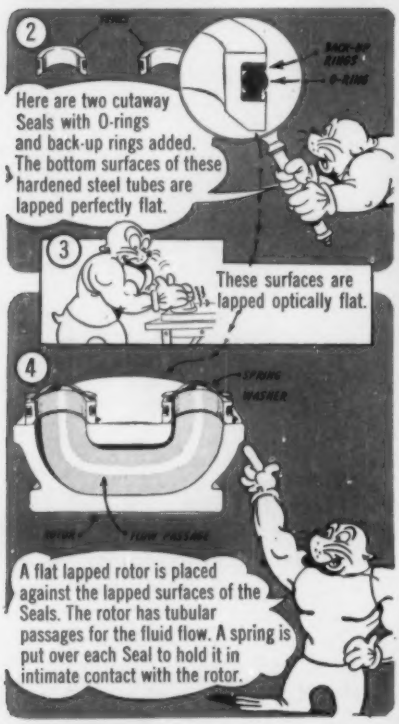
HANDY & HARMAN
850 Third Ave. New York 22, N. Y.

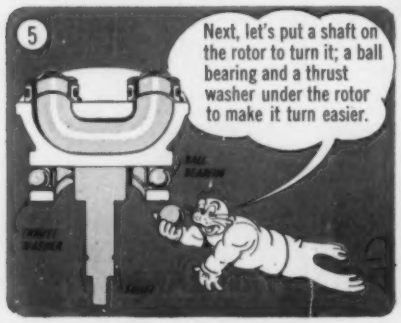
CIRCLE 89 ON READER SERVICE CARD

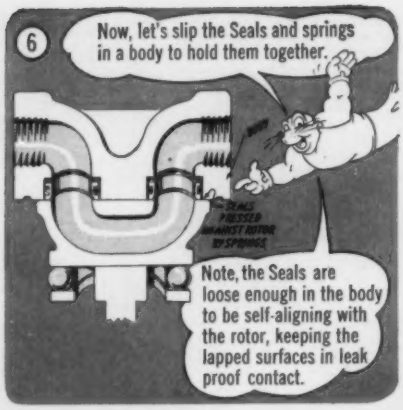
The patented 'Shear-Seal' principle

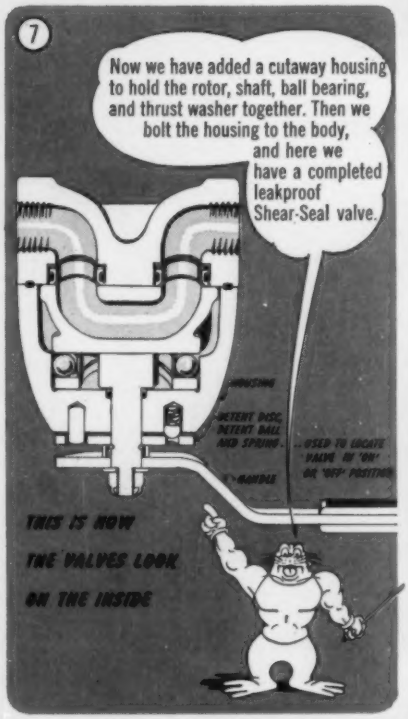
AS EXPLAINED BY... SUPER SEAL

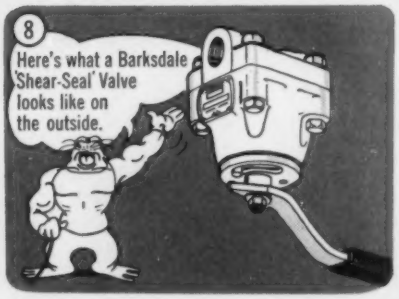

1
First let's cut some of the parts of a Barksdale manual valve in half so that, as we assemble the valve, you can see how the internal parts function.
CUTAWAY VALVE BODY
HOUSING
CUTAWAY ROTOR

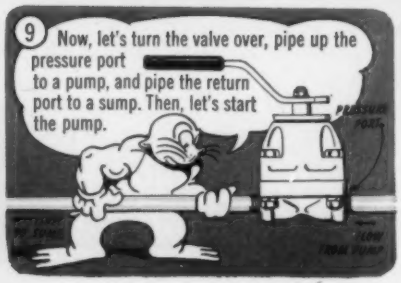

2
BACK-UP RINGS
O-RING
Here are two cutaway Seals with O-rings and back-up rings added. The bottom surfaces of these hardened steel tubes are lapped perfectly flat.
3
These surfaces are lapped optically flat.
4
SPRING WASHER
FLOW PASSAGE
A flat lapped rotor is placed against the lapped surfaces of the Seals. The rotor has tubular passages for the fluid flow. A spring is put over each Seal to hold it in intimate contact with the rotor.

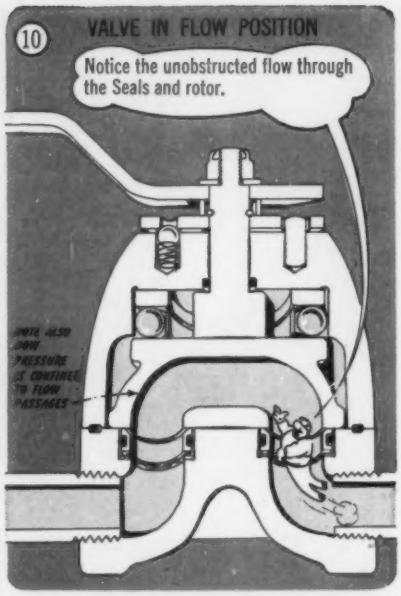

5
Next, let's put a shaft on the rotor to turn it; a ball bearing and a thrust washer under the rotor to make it turn easier.
BALL BEARING


6
Now, let's slip the Seals and springs in a body to hold them together.
SEALS PRESSED AGAINST ROTOR BY SPRINGS
Note, the Seals are loose enough in the body to be self-aligning with the rotor, keeping the lapped surfaces in leak proof contact.


7
Now we have added a cutaway housing to hold the rotor, shaft, ball bearing, and thrust washer together. Then we bolt the housing to the body, and here we have a completed leakproof Shear-Seal valve.
HOUSING
DETENT DISC, DETENT BALL AND SPRING
HANDLE
USED TO LOCATE VALVE IN "ON" OR "OFF" POSITION
THIS IS HOW THE VALVES LOOK ON THE INSIDE




9
Now, let's turn the valve over, pipe up the pressure port to a pump, and pipe the return port to a sump. Then, let's start the pump.
PRESSURE PORT
FLOW TO/FROM PUMP


10
VALVE IN FLOW POSITION
Notice the unobstructed flow through the Seals and rotor.
NOTE ALSO HOW PRESSURE IS CONTINUED TO FLOW PASSAGES

11
Now, let's move the handle – shear the flow and see how the 'Shear-Seal' Valve gives its leakproof service.
SINCE ROTOR AND SEAL ARE BOTH LAPPED OPTICALLY FLAT, AND HELD IN INITIAL CONTACT BY A SPRING, FLUID CAN'T GET BY AND LEAKAGE IS STOPPED
HANDLE IN BLOCKED POSITION
PRESSURE GETS IN BACK OF SEALS AND FORCES IT AGAINST ROTOR

12
IN SUMMARY
'SHEAR-SEAL' VALVES
have long life and are maintenance-free because:
as the Seal and rotor slide back and forth over each other with use, they keep lapping themselves and seal even tighter.

CONTROL VALVE DIVISION

Barksdale valves

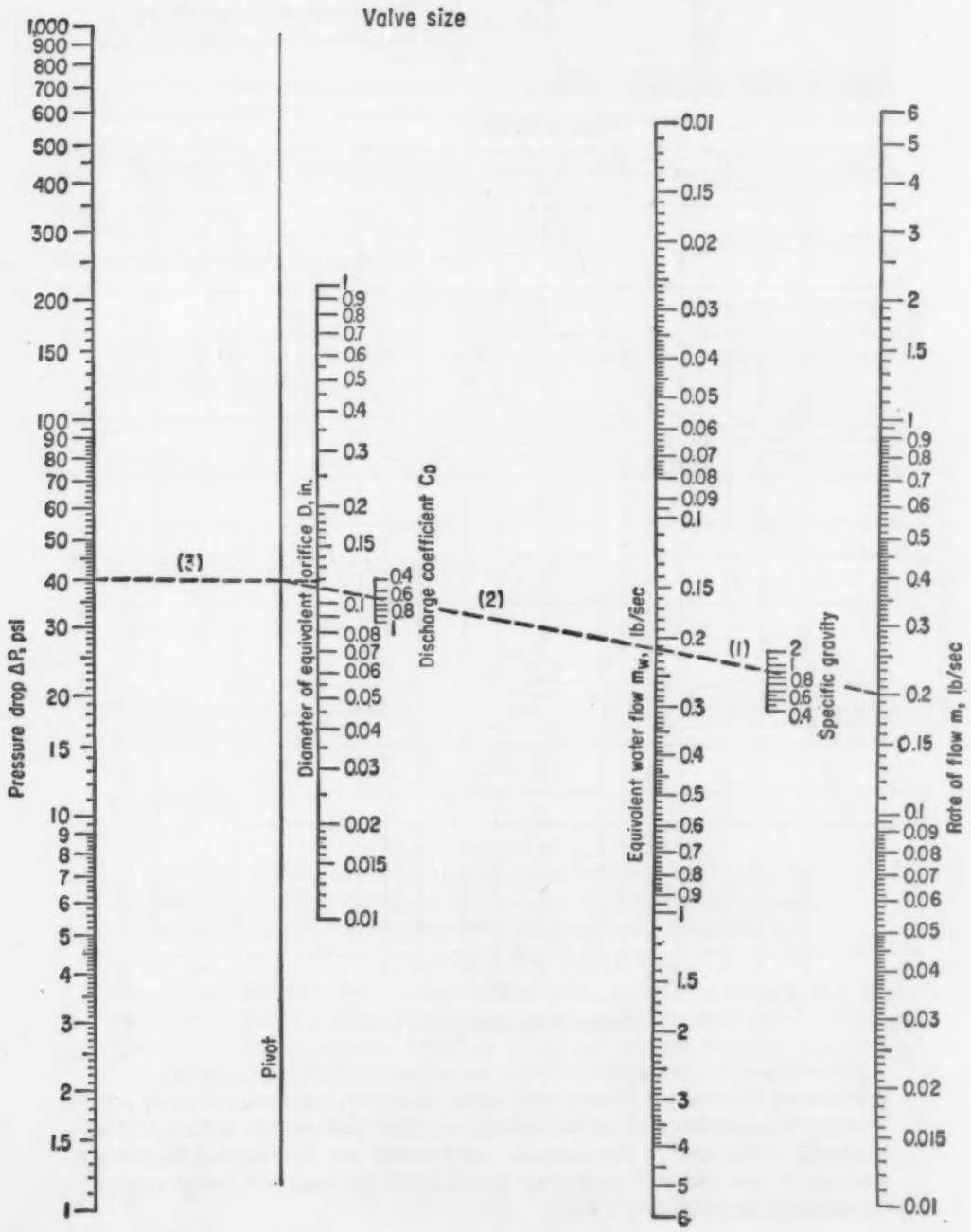
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

Your turn

...to participate in the current problems of our profession.

Several makes and types of valves may be labeled with the same size, yet have such different flow characteristics that the label is useless for comparison. To make a direct comparison easier many manufacturers rate their valves in their equivalent size of standard orifice. Then, you know that two valves rated equivalent to the same size orifice have the same flow characteristics regardless of how differently they are built or what their nominal sizes are.

Dominic J. Lapera, design engineer at Marotta Valve Corp, Boonton, N. J., has devised a nomograph that solves the equation for orifice diameter

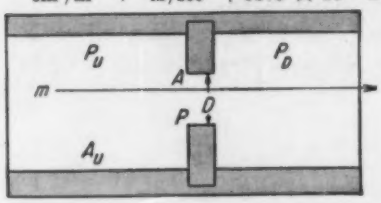


YOUR TURN *continued*

$D = 0.49m^{1/2}/(SC^2{}_D\Delta P)^{1/4}$. He has also sent along a chart for converting D into C_v, because C_v is such a common flow coefficient. For this chart, the equation is $C_v = 17.9\,D^2$.

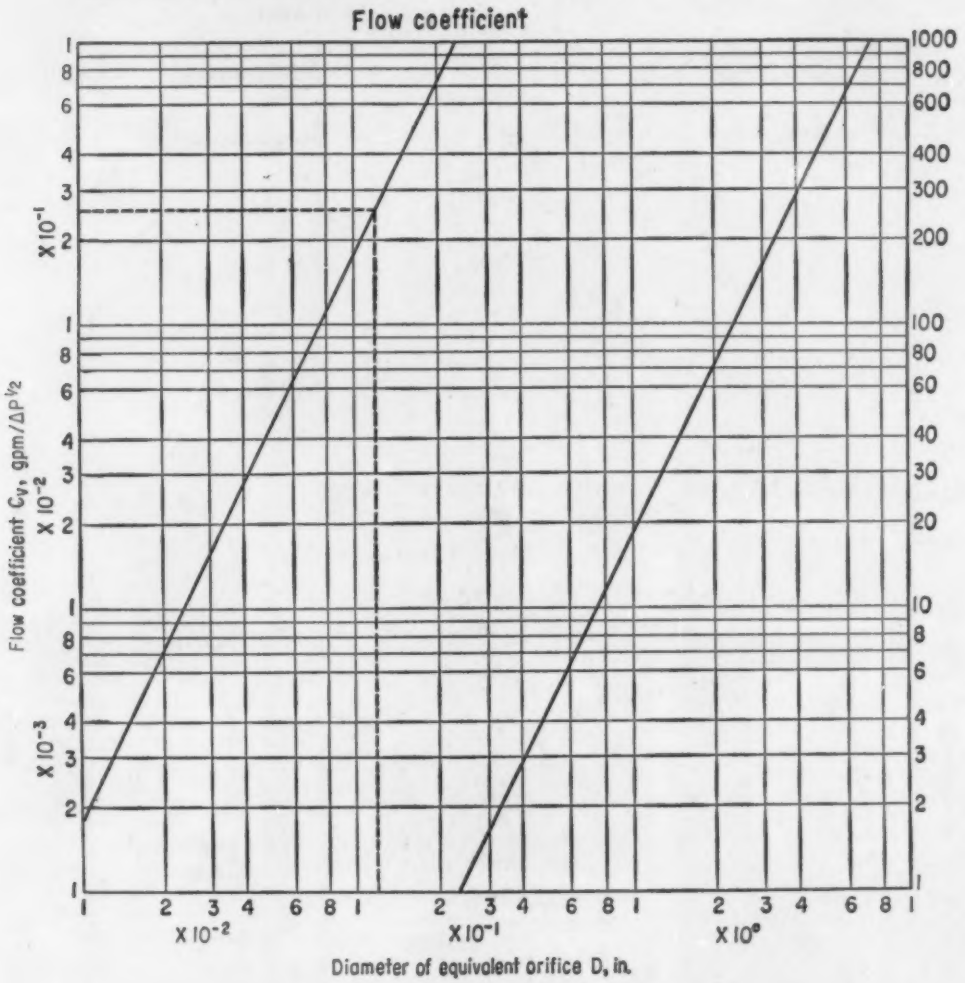
Conversion factors

To convert	into	multiply by
gpm	lb/sec	0.139S
ft³/sec	lb/sec	62.4S
cm³/hr	lb/sec	61.3×10^{-6} S



Symbols

- A = Flow area of equivalent orifice, in.²
- A_u = Flow area upstream from valve, in.²
- C_D = Coefficient of discharge
- C_v = Flow coefficient, gpm/$\Delta P^{1/2}$
- D = Diameter of equivalent orifice, in.
- m = Rate of flow, lb/sec
- P_d = Pressure downstream from valve, psig
- P_u = Pressure upstream from valve, psig
- ΔP = Pressure drop across valve ($P_u - P_d$), psi
- S = Specific gravity of fluid



For example, try this problem: What size valve will handle a 1.6 gpm flow of hydraulic oil ($S = 0.9$) if pressure drop across the valve should not exceed 40 psi? Solution: First, assume a C_D for the equivalent orifice. This can vary from 0.6 for a sharp-edge orifice to 0.95 for a smooth, well-rounded one. By choosing $C_D = 0.6$ you can be sure that any valve rated equivalent to the same size orifice will be big enough no matter what C_D it has.

Next, go to the conversion table to find the factor for changing gpm to lb/sec, and multiply $m = 0.139\ S$ x gpm $= 0.139$ x 0.9 x 1.6 $= 0.2$.

Draw three lines on the nomograph to find $D = 0.12$ which the conversion chart shows to equal $C_v = 0.258$.

• • • •

In our last issue, we began a series of six lessons reviewing **elementary solutions for ordinary differential equations.** Now that we've recalled the terms that classify equations – order, degree, linearity, homogeneity – let's look at the simplest of the lot: **linear, first-order equations, both homogeneous and nonhomogeneous.** Our instructor, as before, is Robert P Benedict, development engineer at Westinghouse Steam Turbine Div., Lester, Pa.

Some linear, first order equations, of course, are too simple to need a special technique. For example, we can solve

$$y' - 6x^2 = O$$

by integrating and immediately write the answer

$$y = 2x^3 + c$$

But others are not so straightforward. Here are two general forms that might cause you some headscratching, but their answers can be written almost as quickly as the example above.

The general form of this first type of **linear, first-order, homogeneous** equation is

$$y' + F(x)\ y = O$$

where F(x) is a function of x only. The variables in such an equation always can be separated, and the expression rewritten

$$\frac{dy}{y} = -F(x)\ dx$$

Integrating this gives the general solution for a linear, first order, homogeneous differential equation

$$ln\ y = -\int F(x)\ dx + c$$

or, rearranging and replacing the constant of integration c with $log_e K$

$$y = K\,e^{-\int F(x)\,dx}$$

Example: Find the solution for the following equation.

$$(x^2 - 3)\ y' + 3xy = O$$

First rewrite in the form

$$y' + \frac{3x}{x^2 - 3}\,y = 0$$

from which it is evident that $F(x) = 3x/\ (x^2 - 3)$. Substitute this into the equation for the general solution

$$y = Ke^{-\int 3x/(x^2-3)\,dx}$$

and integrate

$$y = Ke^{-3/2\ ln\ (x^2-3)} = \frac{K}{(x^2 - 3)^{3/2}}$$

The constant K is determined from the boundary conditions of the problem

The general form of a **linear, first-order, nonhomogeneous** equation is

$$y' + F_1(x)\ y = F_2(x)$$

Clearly, the variables cannot be separated, as before, by dividing through by y. Here we adopt a somewhat different approach. First, express the dependent variable as the product of two unknown functions of the independent variable. Substituting uv for y and $udv + vdu$ for dy gives

$$u\frac{dv}{dx} + v\frac{du}{dx} + F_1uv = F_2$$

or rearranging

$$v\left[\frac{du}{dx} + F_1u\right] + u\frac{dv}{dx} = F_2$$

YOUR TURN *continued*

The advantage of putting the equation in this form is that u can be made any convenient function of x so long as v is then determined accordingly. Specifically, u can be defined such that the bracketed term equals zero. With this choice of u, the equation is rewritten

$$dv = \frac{F_2}{u} dx$$

thus separating the variables. It can be solved easily because, with the bracketed term set equal to zero, $du/dx + F_1 u = O$ is a linear, first order, homogeneous differential equation whose solution is

$$u = e^{-\int F_1 dx}$$

Therefore,

$$v = \int e^{\int F_1 dx} F_2 \, dx + c$$

and with $y = uv$, the general solution for a linear, first order, nonhomogeneous differential equation is

$$y = e^{-\int F_1 dx} \left[\int e^{\int F_1 dx} F_2 \, dx + c \right]$$

Example: Find the solution to the following equation

$$(1-x^2) \quad y' + xy = -ax$$

First rewrite in the form

$$y' + \frac{x}{1-x^2} y = -\frac{ax}{1-x^2}$$

and identify

$$F_1(x) = x/(1-x^2)$$
$$F_2(x) = -ax/(1-x^2).$$

Substitute these in the equation for the general solution

$$y = e^{-\int x/(1-x^2)\, dx} \left[\int e^{\int x/(1-x^2)\, dx} \left(\frac{-ax}{1-x^2} \right) dx + c \right]$$

and write the answer

$$y = (1-x^2)^{1/2} \left[-a \int \frac{x \, dx}{(1-x^2)^{3/2}} + c \right]$$
$$y = -a + c\,(1-x^2)^{1/2}$$

Now you try

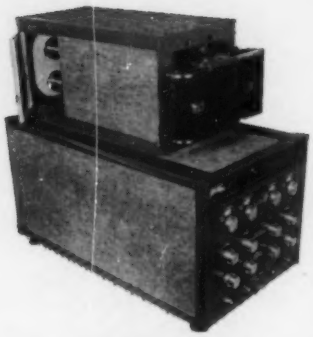
Here are four linear, first-order differential equations. Two are homogeneous and two are nonhomogeneous. The answers will be found on page 117.

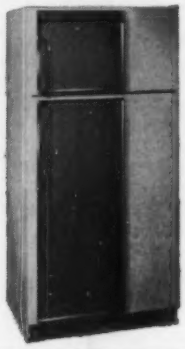
1. $y' - y/x = x$
2. $y' + (\tan x)\, y = O$
3. $(3x^2 + 4)^{1/2} y' = \frac{3y}{x}$
4. $(x^2 + 1)\, y' + 2xy = x^3 + x$

• • • •

Analytical and mathematical solutions have much higher social standing than empirical or graphical ones, particularly in Europe. But there are two types of problems in which it is far easier and quicker to be inelegant. One is illustrated by **the two ladders in an alley.** A 50-ft ladder leans from the base of the building on one side against the building opposite, and a 40-ft ladder leans the other way beside it. They cross 10 ft above the ground. How far apart are the walls? Try that one algebraically and you end with a murderous equation, but trial-and-error solution is simple and converges rapidly.

The second illustration is the old one about the **man who paid a dollar to get into a circus, spent half his money inside, then paid a dollar to get out.** He repeated this routine at second, third and fourth gates, emerged broke. Undertake that by algebra and you have an involved problem; use simple addition, working backwards, **starting at the final exit,** and it's easy.

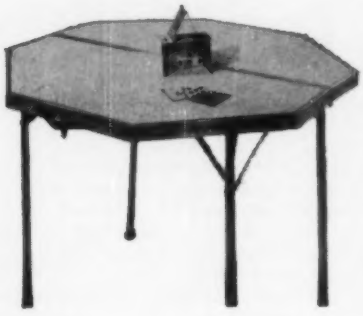




Masland Duran

CLAD

vinyl finish



On just about any product this built-in finish reduces manufacturing costs...boosts saleability

Take the matter of costs. Since Masland Duran Clad is an *integral* finish, you can work with pre-finished parts. That means you can often do away with the need for baking and spraying. No new processing equipment needed, either. This colorful, handsomely designed vinyl can be permanently laminated to metal . . . and cut, crimped, drilled or deep drawn without distortion or marring. As for saleability . . . there isn't anything that excels color-bright, easy-to-clean Clad for attracting immediate and favorable attention to your product. For samples, mail this coupon.

Industrial Products Division

THE MASLAND DURALEATHER CO., Dept. PE-J, Philadelphia 34, Pa.

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The Masland Duraleather Co., Dept. PE-J,
Amber & Willard Sts., Philadelphia 34, Pa.

Please send information and samples of Clad.

Name_____ Title_____

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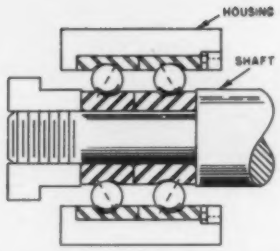
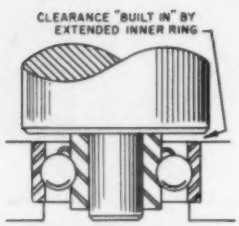
No.1

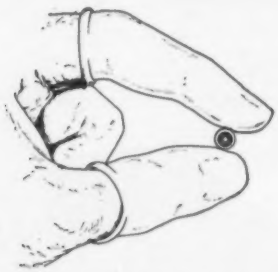
ideas you can use in working with bearings



The problem of confining radial and axial shaft displacement to an absolute minimum in instruments such as gyroscopes can be solved readily by the use of duplex bearings. These "matched pairs", constructed to eliminate axial play, do away with painstaking and time-consuming use of shims mounted against one face of single bearings. Duplex pairs are matched by NHBB to customer specifications.

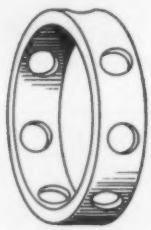


When small bearings are mounted against surfaces such as flat gear faces there must be sufficient clearance to allow the outer ring to revolve independently, especially when there are thrust loads and axial play. NHBB extended inner ring bearings (the inner ring is .0312" wider than the outer) provide ample clearance. They eliminate the need for — and provide a firmer, more precise bearing seat than — washers, sleeves or gear hubs.



Miniature and instrument bearings must be protected in the user's plant so that the precision built into them will be fully realized in an assembled instrument. One form of protection is the use of rubber finger cotts by everyone handling bearings to prevent the corrosion of polished surfaces from skin acids — a serious threat to optimum bearing performance.

Radial play — the displacement of one ring with respect to the other along the diameter of a bearing — is important in the successful application of precision bearings and should be specified on orders. A range of .0002" to .0005" is satisfactory for most applications. The minimum clearance should be .0001" and the total spread from min. to max. should be at least .0002".



Machined type retainers of laminated plastic permit higher speeds than stamped metal retainers and, because of the porosity, act as lubricant reservoirs. Bearings with machined retainers can withstand thrust load in one direction only because either an inner or an outer land must be ground off to permit assembly. Since most applications involve a pair of bearings which can be mounted to oppose one another this limitation is seldom a disadvantage.

150-page Design and Purchasing Manual is the most comprehensive treatise on miniature and instrument ball bearings ever published. Write for your copy — on your company letterhead, please.

TYPICAL SPECIFICATIONS OF NHBB EXTENDED INNER RING BEARINGS

BORE	OUTSIDE DIAMETER	WIDTH INNER	WIDTH OUTER	BEARING NUMBERS	RADIUS	C RATING
.0469 .0550	.1562 .1875	.0937 .1094	.0625 .0781	SR0EE SR1EE	.005 .005	19 28
.0781 .0937	.2500 .1875	.1250 .0937	.0937 .0625	SR1-4EE SR133EE	.006 .005	39 21
.0937 .1250	.3125 .2500	.1406 .1250	.1094 .0937	SR1-5EE SR144EE	.006 .005	64 36
.1250 .1250	.3125 .3750	.1406 .1406	.1094 .1094	SR2-5EE SR2-6EE	.006 .006	66 66
.1562 .1875	.3125 .3125	.1406 .1406	.1094 .1094	SR155EE SR156EE	.005 .005	35 35
.1875 .2500	.3750 .3750	.1562 .1562	.1250 .1250	SR166EE SR168EE	.008 .008	82 44
.2500 .3125	.5000 .5000	.1562 .1875	.1250 .1562	SR188EE SR1810EE	.010 .009	120 60

ALSO AVAILABLE IN FLANGED AND SHIELDED CONSTRUCTION.

NEW HAMPSHIRE BALL BEARINGS, INC.
PETERBOROUGH, N. H.

new instrument bearings let you beef up the shaft without increasing bearing O.D.

Here are four new opportunities to design shaft-to-housing relationships not possible with other bearings. Thinner cross sections permit extra large bore-to-O.D. ratios.

This new series is manufactured to ABEC-5 precision standards or better, of 440C stainless steel, with plastic crown retainers which act as lubricant reservoirs.

BORE +.0000 −.0002	OUTSIDE DIAMETER +.0000 −.0002	WIDTH +.000 −.001	BEARING NUMBER	RADIUS	BALLS NO.	BALLS SIZE	C RATING
.3750	.6250	.1562	SR6Z9T	.010	12	1/16	81
.5000	.7500	.1562	SR8Z4T	.010	16	1/16	95
.6250	.8750	.1562	SR10Z0T	.010	18	1/16	98
.7500	1.0000	.1562	SR12Z2T	.010	22	1/16	108

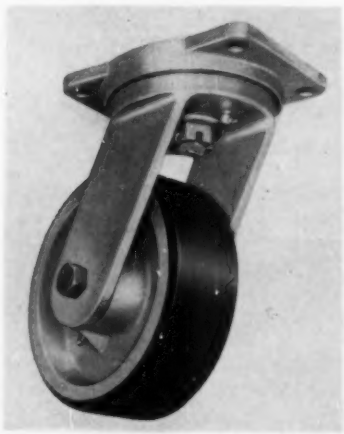
NEW HAMPSHIRE
BALL BEARINGS, INC.
PETERBOROUGH, N. H.

directs a portion of oil over the poppet where it rejoins that portion of oil directed through filter element. Available in three basic sizes and variety of porting arrangements with flow capacities up to 300 gpm. **Vickers Inc, Div of Sperry Rand Corp, Detroit 32.**

Circle 323 on Reader Service Card

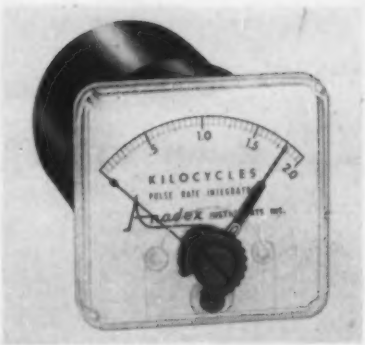
Disk brake . . .
is low-cost unit available from stock for wide range of industrial machinery and small vehicles. Furnished with 7-, 12- and 18-in. disks to give range of torque capacity up to 9000 lb-in. and kinetic energy capacity up to 1 million ft-lb. Can be applied by hydraulic or pneumatic action and has universal mounting configuration that allows mounting of brake housing on almost any existing support. Equal torque forward or backward and automatic adjustment to compensate for lining wear also are engineered into unit. **Goodyear Tire & Rubber Co, Akron 16, Ohio.**

Circle 324 on Reader Service Card



High capacity casters . . .
both swivel and rigid are equipped with synthetic urethane elastomer tread wheels. Wheel diameters range from 4 to 12 in. and treads widths from 1½ to 4 in. Wheel capacities are from 500 to 4000 lb each. Swivel locks and wheel brakes are optional on many models and tapered roller bearings are available in wheels 6 in. or larger. Wheels, which can be ordered separately or in casters are said to outwear ordinary rubber 5 to 10 times. Tread material resists corrosion and is noiseless, non-marking and impervious to oil, brine and most solvents. **Hamilton Caster & Mfg Co, 1700 Dixie Hwy, Hamilton, Ohio.**

Circle 325 on Reader Service Card



Frequency meter relay . . .
combining a frequency converter and meter relay, permits preselection of frequency which will actuate external controls, such as alarm, on-off, signalling, etc., or any other control function. Available as continuous reading type in which meter continues to read past set point to full scale and as locking type in which meter stops reading at set point and will not reset itself until frequency signal returns to set point. Has input sensitivity of 10 mv rms and accuracy of 1%. Standard full-scale frequencies range from 50 kc down to 50 cps. Prices start at $125, with delivery in 30 days. **Anadex Instruments Inc, 14734 Arminta St, Van Nuys, Calif.**

Circle 326 on Reader Service Card

High current switches . . .
make and break 25 amp at 125 or 250 v ac in SPDT circuits. Available in basic style with pin actuators, and with overtravel plunger, leaf, leaf roller, lever and roller-lever actuators. Base styles include solder-lug terminals, step base and screw terminals and front-facing screw terminals. Molded phenolic case is 1 1/8 x 1 1/8 x 1 1/8 in. Mounting holes accept 0.139-in. dia pins or screws on 1-in. centers. **Unimax Switch, Div of Maxson Electronics Corp, Ives Rd, Wallingford, Conn.**

Circle 327 on Reader Service Card

Back pressure regulators . . .
are suitable for 250 psi at 500 F in ductile iron, bronze and monel bodies; 50 psi at 300 F in aluminum body; and 300 psi at 600 F in stainless and cast steel bodies. Self-operated units maintain constant upstream or inlet pressure regardless of pressure fluctuations and are said to provide tight shut-off and accurate control during operation. Include self-lapping, self-cleaning, sliding gate seats. Control ranges are from 3 to 170 psi. From stock in ¼- to 2-in. sizes at $73 to $450. **OPW-Jordan, 6013 Wiehe Rd, Cincinnati 37.**

Circle 328 on Reader Service Card

the secret of Ford's swing-away wheel

The secret of the new swing-away steering wheel in the Ford Thunderbird is a flexible shaft between the stub shaft in the steering gear box and the upper steering rod.

Here are the benefits derived from flexible shafts:

1. *Safety*. Safety against failures is provided.

2. *Durability*. Flexible shafts eliminate the possibility of play or lost motion at this juncture for the life of the car.

3. *Compact*. The flexible shaft is more compact than conventional joints.

4. *Strength*. In case of power steering failure, the maximum torque would be 660 pound-inches, which would occur during parking on dry pavement. The flexible shaft can absorb this and *much more*.

Here is another example of creative engineering with flexible shafts. Investigate for yourself how they can solve many of your design problems and at the same time reduce costs.

S. S. WHITE INDUSTRIAL DIVISION,
DEPT. 14 10 East 40th Street, N. Y. 17, N. Y.

THE S. S. WHITE FLEXIBLE SHAFT HANDBOOK
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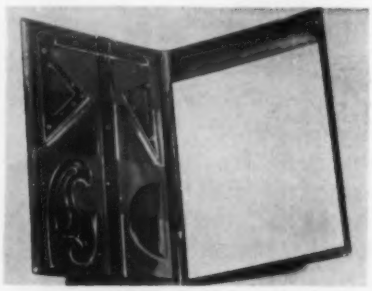
EQUIPMENT

Switching and balancing unit . . . is a 10-channel instrument that permits bridge balancing and fast switching of strain gages or gage configurations into a strain indicator. Said to be useful when readings must be taken on each of a group of gages and where time is short because of limited availability of testing facilities, ambient temperature variations, creep, or other characteristics of the test material. Among features: individual gage bridge balancing; provision for full and half bridge configurations; selectivity for gage resistances of 60 to 500 ohm on full bridge, 60 to 2000 ohm on half bridge; and provision for measurements to be made during same test with both two- and four-arm bridges. Unit has balancing range of ±7000 microin. per in. and repeatability of better than 1 microin. per in. after a ½ million channel selector switch rotations. Weighing 12 lb, it is enclosed in a Formica case 12 x 8½ x 7½ in. **Electronics & Instrumentation Div, Baldwin-Lima-Hamilton Corp, 42 4th Ave, Waltham 54, Mass.**
Circle 329 on Reader Service Card



Drafting instrument portfolio . . . is filled with transparent plastic pockets to hold drafting instruments, pad and pencil. Instruments include 30/60° and 45/90° triangles, a laminated protractor, a French Curve and a 12-in. calibrated T-square with inch and millimeter scales. One pocket can hold a 9 x 12-in. drawing or tracing pad. Portfolio measures approx 19 x 13½ in. when open; 9½ x 13½ in. when closed. Made of vinyl and priced at $3.50. **C-Thru Ruler Co, 827 Windsor St, Hartford, Conn.**
Circle 330 on Reader Service Card

Semiconductor cooler kit . . . contains representative types of coolers, including natural convection units and forced convection modular package. Both complete units and modular components are supplied, enabling

continued, page 100

GRAPHITAR®

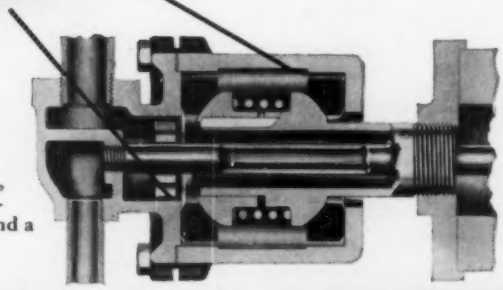
(CARBON-GRAPHITE)

FOR PERFORMANCE

Superior performance and unusually long service life, even in tough applications, is practically second nature to parts made of GRAPHITAR. That's because they combine GRAPHITAR's chemical stability, heat resistance, low coefficient of friction, adaptability to self-lubrication, mechanical strength, hardness and light weight. An everyday application of GRAPHITAR that illustrates well its versatility and remarkable performance can be found in the face-type valves employed in bulk station gasoline meters. These valves incorporate GRAPHITAR seats.

Here, GRAPHITAR's corrosion resistance, chemical inertness and resistance to expansion or contraction under rapid temperature changes, allow the valves to provide a leak-tight seal with excellent wear characteristics. These same characteristics are necessary for good performance wherever steam, gas and chemicals must be handled under the most adverse conditions. Perhaps your product can benefit from the top performance of GRAPHITAR, a unique and versatile engineering material.

R-302-1



Self-aligning seals of GRAPHITAR are employed in rotary pressure joints handling steam, water, hot oil, trichlorethylene, powdered talc and a variety of chemicals.

Comparative testing of various grades of GRAPHITAR self-aligning seals is accomplished on this equipment, which duplicates actual operating conditions. GRAPHITAR rotary pressure joint seals such as these often operate at 400 psi, at 650°F. and at rotary speeds of 600 ft/min.

GRAPHITAR is a material uniquely designed by its nature for solving tough problems and improving processing, and it can be further custom-engineered to meet your exact specifications. For complete information on GRAPHITAR . . . send for Engineering Bulletin #20.

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DIVISION OF THE WICKES CORPORATION, SAGINAW 1, MICHIGAN

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High tensile strength floats . . . spherical, elliptical or cylindrical.

Uniformly thick walls because float halves are die-formed . . . not spun, laminated or electro-deposited.

Versatile use . . . for buoyancy mediums, fluid chambers, pressure vessels, and all mechanisms requiring floats.

Made for working pressures up to 2500 lbs., Nicholson floats range from 2″ to 12″ in diameter and have exceptional resistance to pressure and corrosion. *Steel Floats:* chromium, cadmium or copper plated. Also unplated, with sandblast or pickled finish. *Stainless Steel and Monel Floats:* rough buffed or polished with smooth, highly finished welds.

This Coupon Brings You Informative Bulletin On Floats

Bulletin 753 contains facts on steel, stainless steel and monel floats, information on float connections, tables showing weight, buoyancy and collapsing pressure for spherical floats for all gauges . . . also volume and buoyancy data. Fill in and mail this coupon for your copy.

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NICHOLSON
of Wilkes-Barre

designer to conduct tests using his own circuitry within physical layout and environment desired. Furnished with technical data at $38.50. **Delta-T Semiconductor Cooling Div, Wakefield Engineering Inc, Wakefield, Mass.**

Circle 331 on Reader Service Card

O-ring template . . .
aids in drawing cross sections and specifying O-rings and O-ring grooves. Template is pocket size, made of semi-opaque plastic. Duplicates cross section pattern of O-rings and grooves in actual, twice and four times size. Also carries dimensional and tolerance information. Priced at $1. **Parker Seal Co, Div of Parker-Hannifin, 10567 Jefferson Blvd, Culver City, Calif.**

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Thermistor thermometer . . .
is an automatic switching unit that permits fast, consecutive temperature measurements at several locations on same subject or at similar locations on multiple subjects. Available in either 3, 4, 6, or 12 channels; has response up to 0.4 sec per 20 C change and accuracy of 1% full scale deflection. Direct reading scale is supplemented by an output connection for simultaneous recording with any standard recorder. Each channel operates independently and has its own calibration controls. Automatic sequential switching between channels at 15-, 30- and 60-sec intervals is provided. **Waters Corp, PO Box 529, Rochester, Minn.**

Circle 333 on Reader Service Card

Electronic circuit template . . .
made of butyrate plastic provides transistor and diode symbols in addition to those for electron tubes and electronic components. Symbols are in accordance with MIL, ASA and IRE standards for electronic and semiconductor graphic symbols and are sized for 0.2-in. grid. Priced at $4.95. **Quintec Instrument Co, Box 85, Altadena, Calif.**

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At Lamb Electric...Engineers with FHP motor "know-how" solve intricate design problems

At Lamb,® every fractional horsepower motor design problem is special. Because the problems are special, Lamb engineers funnel their years of "know-how" into each intricate project. The result: unusual benefits for you.

Fractional horsepower motors from Lamb incorporate the best possible design, flexibility, and production economy.

If you have a special motor problem . . . here's what you can expect from Lamb. Into the design goes years of experience in power components for aircraft, domestic and industrial products. Out of the design comes a personalized motor that's dependable, smooth and efficient.

Cost-wise, you're way ahead, because Lamb Motors are mass-produced at the most favorable cost.

Write today for descriptive folder. Or ask to have a District Engineer call and set up a personalized "Motor Conference".

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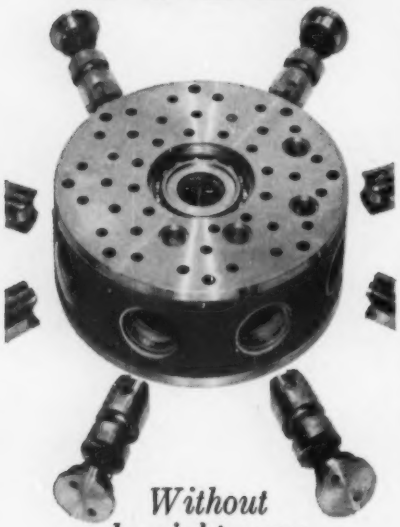
Sine Qua Non



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DESIGN LITERATURE

Mathematical Handbook For Scientists and Engineers

GRANINO A KORN & THERESA M KORN. McGraw-Hill Book Co, Inc, 330 *W* 42 *St, New York* 36. 6¼ *x* 9¼, 943 *pp.* $20.00.

A reference book for all phases of advanced math likely to be needed by scientists and engineers. Elementary math is covered too, but treatment of these topics (algebra, plane and solid geometry) is confined to the first 80 pages. The remaining 650 pages discuss such subjects as vector analysis, complex variables, Laplace transformations, tensor analysis, matrices, random processes, statistics.

Of special interest are: a list of criteria locating roots of algebraic equations, a table summarizing properties of Fourier transforms, contour integration, boundary and Eigenvalue problems, estimation, and a list of special solutions for partial differential equations. Important definitions and formulas are collected in tables and boxed in groups for rapid reference and review. The appendix includes integral tables, logarithms, numerical functions and statistical distributions.

Response of Metals to High Velocity Deformation

Edited by P. G. SHEWMON, V. F. ZACKAY. Interscience Publishers, 250 *Fifth Ave, New York* 1. 9¼ *x* 6. 491 *pp.* $18.

The use of high strain rates to deform metals and to change their properties has concentrated on solving practical problems. This book, a summary of an AIME Conference, tries to pin down the various factors which influence the mechanism of metal deformation at high velocities.

The text is divided into two parts: deformation at high velocities on mechanical testing machines; effect of shock waves on metals from explosives and other methods. One important contribution of the book is its standardization of symbols and terminology used in the text.

The book is a thorough discussion of fundamentals but has little information directly usable in the design of parts.

Engineering Drawing and Geometry

RANDOLPH P HOELSCHER, CLIFFORD H SPRINGER. John Wiley & Sons, Inc, 440 *Park Ave S, New York* 16, 8⅜ *x* 10¼, 350 *pp.* $8.95.

This is the second edition of this popular textbook. Besides the usual material on projections, sketching, use of instruments, and dimensioning, the book includes chapters on engineering geometry, perspective drawing, charts and diagrams, graphic layouts for empirical equations, and construction of nomographs. Also there is a section on professional applications such as map drawing, structural drawing, pipe drawing, welding drawing and patent office drawing. The illustrations are large with legible lettering to make best use of the larger-than-average pages (8 x 10 in.). An appendix includes standard drafting room data such as twist drill sizes, dimensions of nuts and bolts, dimensions of standard structural shapes, graphic symbols.

Bearings for High Temperature Service

W. F. O'ROURKE, General Motors Corp. (*PB*-171151, *WADD Technical Report* 60-46.) *Office of Technical Services, US Dept of Commerce, Wash* 25, *DC.* 8¾ *x* 10¾, 131 *pp.* $2.75.

The assignment (fulltitle: "Research on Developing Design Criteria for Anti-friction Airframe Bearings for High-temperature Use.") was to screen materials and lubricants to find a roller bearing combination that would take 40,000 oscillations at 600 to 1200 F and 500,000 psi compressive stress. Although none of the material fulfilled the target requirements, some lasted for 27,000 cycles at 250,000 psi and 900 F or 40,000 cycles at 165,000 psi. Of the materials tested, the most promising for 900 F were M-2 Tool Steel or 440-CM stainless for races and K-161 TiC for the balls. At 1200 F the best materials were CR-2 Cr Carbide for races and Stellite Star J for the balls. None of the 25 lubricant combinations added significant wear life to roller bearings at high temperatures.

Other Books of Interest

Turning Points in Physics

Blin-Stoyle, TerHaar Mendelsohn, Temple, Waismann, Wilkinson. Harper & Brothers, 49 *E* 33*rd St, NY* 16. 5¼ *x* 8, 192 *pp.* $1.45.

Paperback edition of book originally published in 1959.

Casualty and Chance in Modern Physics

David Bohm, Harper & Brothers, 49 *E* 33*rd St, NY* 16. 5¼ *x* 8, 170 *pp.* $1.35

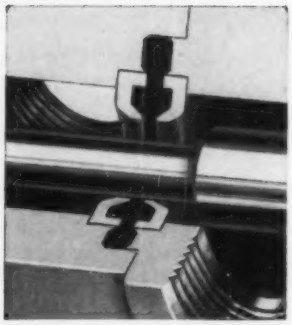
Paperback edition of book originally published in 1957.

The Radio Amateur's Handbook

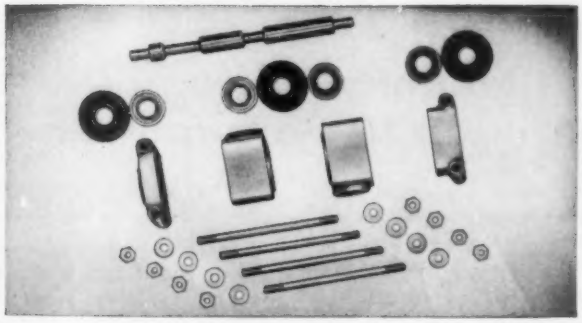
American Radio Relay League, West Hartford, Conn. 6½ *x* 9½, 724 *pp.* $3.50

continued, page 105

Do the air valves you buy include these quality features?



SEAL—Exclusive, triple-supported seals permit interference fit of spool for extra-tight closure with minimum wear. Usual damage to conventional "O" rings by moving spool is eliminated.



SIMPLICITY—Uncomplicated parts mean long life and easy servicing. Common parts are used extensively to simplify stocking or repair.

FLEXIBILITY—Modular Construction. Operators, mounting holes and ports may be independently rotated in 90° steps. Operator may be on either or both ends.

This high-quality "D" Pilotair® Valve is available in thousands of combinations. Tailored valves at standard model prices. Nine basic valves may have one or two of eight operators. Many types of spring return or holding functions.

if not, the chances are your maintenance costs are higher than necessary. For more information about quality Fluid Circuitry Controls for trouble-free automation, ask for Catalog A4-75.01.

See the Yellow Pages under Cylinders for the Name of Your Local Distributor, or refer to Sweet's Catalog, Product Design File.

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WAGNER Polyphase Resilient Mounted Motors in ratings through 10 horsepower

Quiet, vibration-free performance is essential when motors are installed in areas where noise must be held to a minimum . . . in hospitals, churches, schools, office buildings, restaurants and similar locations where quiet is needed or wanted.

Such installations have created a need for larger polyphase motors that whisper while they work. Wagner has met this need by expanding its line of polyphase resilient mounted motors to include standard ratings through 10 hp.

You certainly have applications that call for a smooth running motor, cushioned by resilient mountings. To make sure they're quiet, specify Wagner Polyphase Resilient Mounted Motors. Only Wagner can provide an entire range of ratings through 10 hp.

Constant research and development have kept Wagner up front in electric motor design for more than 65 years . . . made the name Wagner one you can depend on in choosing electric motor drives.

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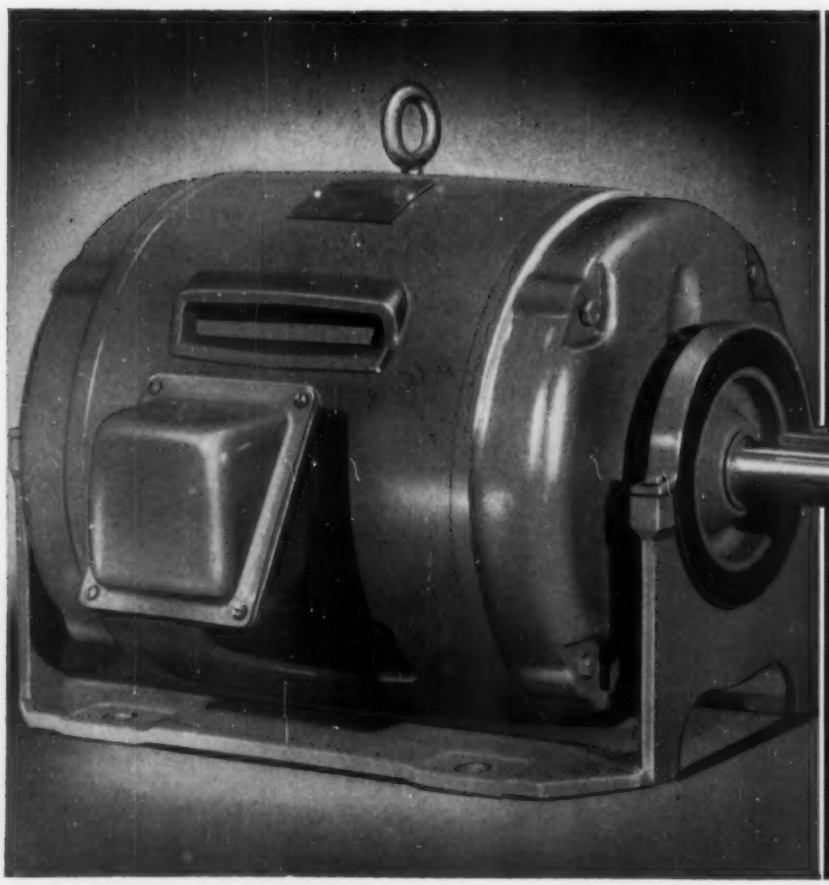

SLEEVE OR BALL BEARING
These motors are furnished with quiet running steel-backed babbitt-lined sleeve bearings of high load carrying capacity. Ball bearings can be supplied when desired.

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You can mount these motors on walls or ceilings by rotating the cradle base 90° or 180°. Motor stays dripproof.

NEOPRENE CUSHIONING RING
Annular mountings, of oil-resistant neoprene bonded to steel rings, cushion the motor in its cradle base to absorb the small amount of vibration that remains in the most carefully balanced motor.

A History of the Theories of Aether & Electricity (2 Vols)

Sir Edmund Whittaker. Harper & Brothers, 49 E 33rd St, NY 16. 5¼ x 8, Vol 1, 434 pp, $1.95; Vol. 2, 319 pp, $1.85

Paperback edition of the original work published in 1910.

ABSTRACTS

Effect of Sunlight On the Corrosion of Steel

Laboratory tests were made which showed that the corrosion rate of steel is greater under a blue filter than under a red filter in the presence of sunlight, provided that a thin film of water covers the metal surfaces. Outdoor tests of four-months duration verified the laboratory results. Steel specimens were exposed under molded glass filters which transmitted radiation within specific spectral regions. The results indicate that ultraviolet light activates the metal surface so that corrosion is initiated sooner or progresses at a faster rate than it would in its absence. Infrared light affects the metal surface so that subsequent exposure to ultra violet light does not produce the same increase in corrosion.

"Effect of Sunlight On the Corrosion of Steel," by Leonard C. Rowe, General Motors Corp, Corrosion, June '61, 1061 M & M building, Houston 2, Texas.

Permanent Magnets

Discusses typical stability characteristics of permanent magnets and methods used to achieve stability in dynamic applications.

"Stability of Permanent Magnets," by J. W. Beard, Beard & Fitch Ltd. Mechanical World, August 1961, 31 King St, W, Manchester 3, England.

Motor Enclosures

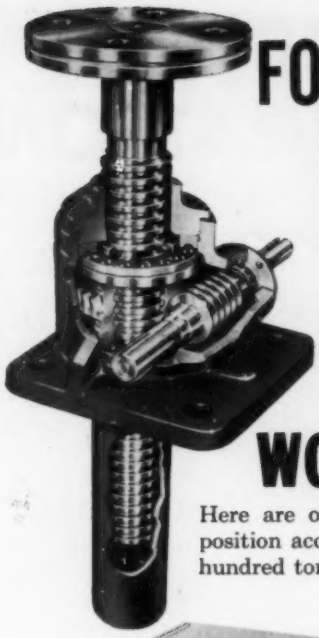
Discusses how much enclosure is needed for safe operation of today's almost completely sealed motors. Describes possible causes of sparking and explains UL methods of classifying hazards. Totally enclosed and explosion-proof motors are compared.

"How Much Motor Enclosure for Hazardous Areas?", by D. N. High, Motor and Generator Dept, D. K. Russel, Norwood Works, Allis-Chalmers Mfg. Co., Allis-Chalmers Electrical Review, Second Quarter, 1961, Milwaukee 1.

Thin-film Thermometer Measurements

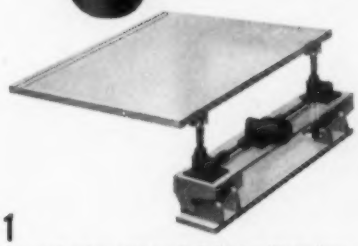
In a recent experimental shock-tube study of the processes of boundary-layer transition and heat trans-

continued, page 109



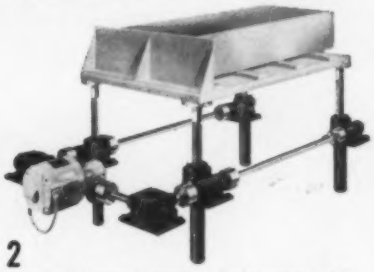
FOR ACCURATE MOVEMENT OF LOADS...USE DUFF-NORTON WORM GEAR JACKS

Here are only four examples of the many ways to position accurately loads weighing as much as several hundred tons with Duff-Norton Worm Gear Jacks.



1

An application with two Duff-Norton Worm Gear Jacks mounted on swivel subbase and each lifting screw end fastened to hinged member by means of clevis and pin. Jacks may be motor driven or manually operated.

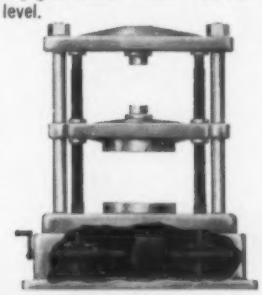


2

Four Duff-Norton Worm Gear Jacks connected in rectangular arrangement by Duff-Norton Mitre Gear Boxes, shafting and flexible couplings and driven by gear motor to raise metal sheets to press level.

3

Six Duff-Norton Worm Gear Jacks as used on pipe-cut-off and threading machines to adjust height of machine spindle to level of conveyor table to compensate for various sizes of pipe.



4

Platen pressure obtained positively and uniformly by two Duff-Norton Worm Gear Jacks with rotating screws.

There are eight standard models of these jacks—capacities range from 2 to 100 tons, with standard raises up to 24 inches.

For engineering drawings of standard jacks, mitre gear boxes and more examples of how Duff-Norton Worm Gear Jacks are used for accurate movement of loads, write for Bulletin AD-66a-DD.

DUFF-NORTON JACKS

DUFF-NORTON COMPANY

Four Gateway Center, Pittsburgh 22, Pennsylvania

The Canadian Duff-Norton Co., Ltd., Toronto 6, Ontario

DUFF-NORTON JACKS
Ratchet • Screw
Hydraulic • Worm Gear

DUFF-NORTON

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Ratchet Lever • Air
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CIRCLE 105 ON READER SERVICE CARD 105

No. 2 in a series

VIBRATION NOTES

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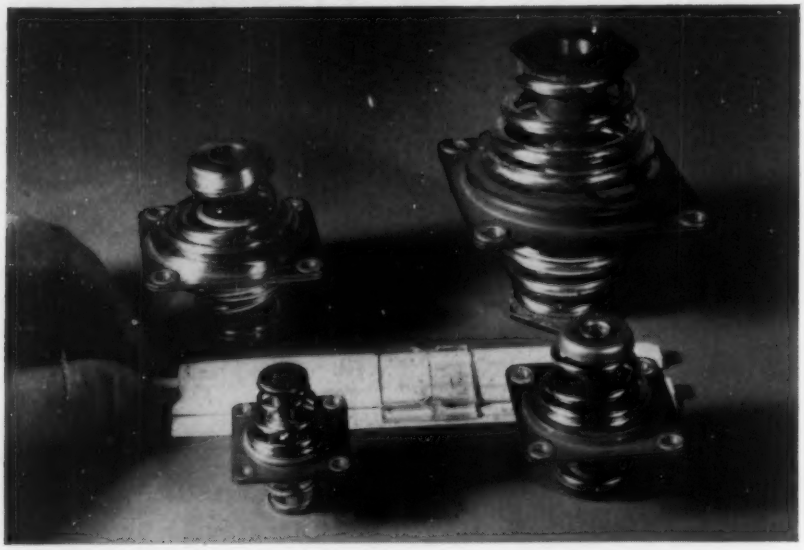


MB's Iso-Damp Spring Mount Now Available in 4 Sizes

combines low frequency damping with high frequency isolation

The unique vibration isolation characteristics of the MB Iso-Damp Spring Mount can now be applied to a wider range of applications with the recent design of 3 new sizes, covering a spring rate range of 14 lbs./in. to 500 lbs./in. and load capacities up to 50 lbs. per mount.

The Iso-Damp principle combines low frequency damping with high frequency isolation. Damping is provided in all three directions through friction obtained from sliding contact between brake lining material and metal surfaces. Sufficient damping is provided to limit magnification at resonance to 5 to 1 at low input amplitudes and to much lower magnification levels at higher inputs.

The unique damper design results in equal and controlled damping in any direction of vibration excitation. Damping elements are amplitude sensitive so that friction damping occurs only in the region of resonance. Above this region the damping elements become inoperative, thus permitting maximum isolation.

MB Iso-Damp Spring Mounts are constructed of materials chosen for their thermal stability, as well as their isolation and damping characteristics. The mounts will perform at continuous operating temperatures from –100°F to 500°F.

The Iso-Damp unit will withstand high shock loads without mechanical failure or impairment of performance characteristics. The interlocked design of metal parts assures that the equipment will be "failsafe" under even more severe shock conditions.

Write for Mount Catalog to Isomode Division, MB Electronics, P.O. Box 1825, New Haven 8, Conn.

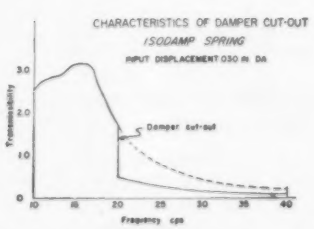
The Importance of Damping in Isolation

Although damping is primarily the concern of the isolator designer, the equipment designer would be well advised to know something about the effect of damping on the overall isolation of his system. Even in the best environment some damping is necessary. There are always instances when the forcing frequencies correspond to the natural frequencies of the system. Without damping, magnification of amplitude and forces due to resonance would result, causing damage to the equipment or the isolator.

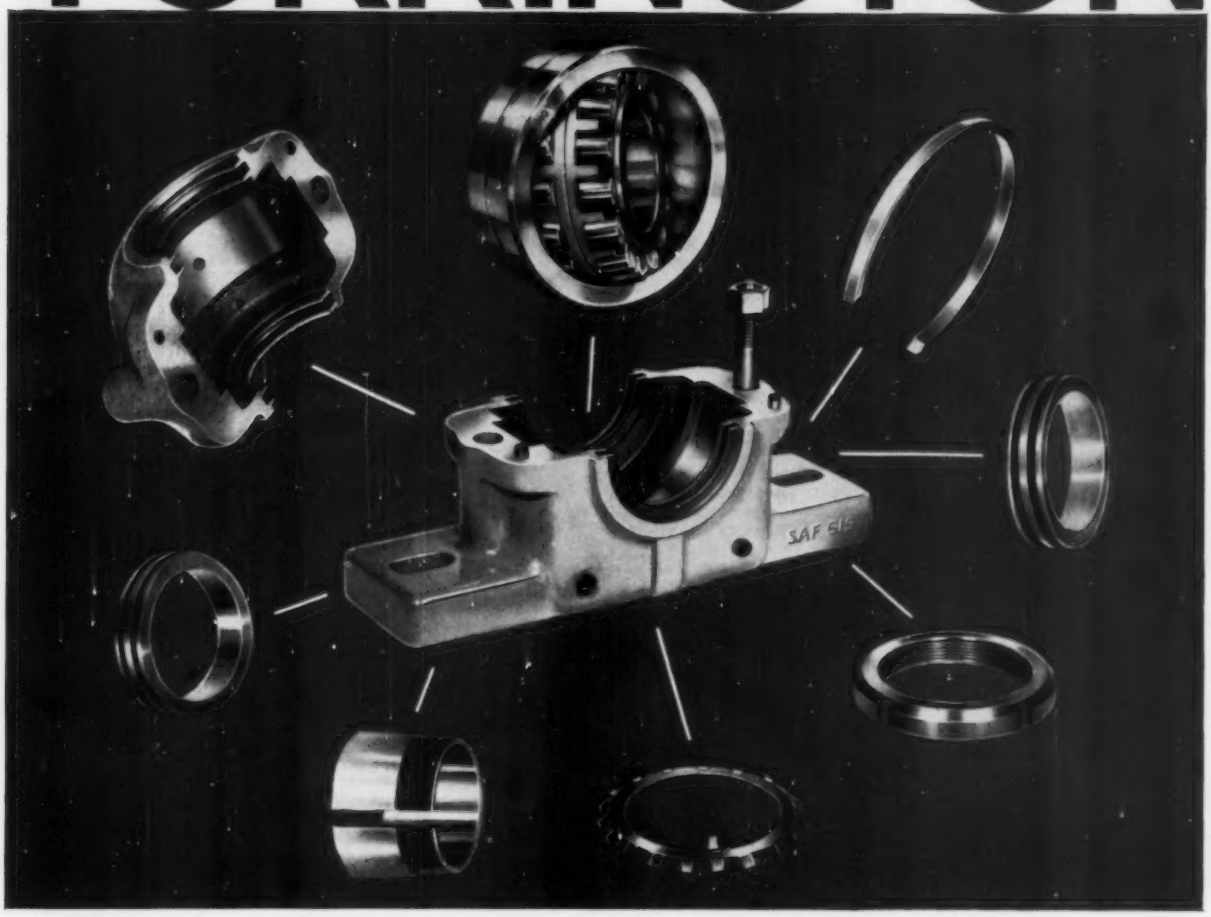
While damping will reduce the amount of magnification due to resonance, it can also produce undesirable side effects. The best way to isolate is to avoid restraining a deflection. Damping involves restraint, resulting in the transmission of unwanted displacements or forces through the isolator. Consequently, in the region where the isolator is cushioning the forces or deflections it is not as effective as it could be without damping. However, in the region where the isolator is "bobbling" at its natural frequency damping prevents the "bobble" from becoming destructive.

There are three basic types of damping, each having its advantages for particular applications: 1. Solid damping or hysteresis damping, such as provided by rubber; 2. Viscous damping, such as a dashpot; and 3. Dry friction or coulomb damping, characterized by the Isodamp spring mount.

The curve below indicates how the Isodamp unit applies friction damping in the region of resonance and cuts out at higher frequencies to permit maximum isolation.



TORRINGTON

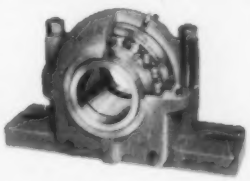


TORRINGTON SPHERICAL ROLLER BEARING PILLOW BLOCKS ...THE INSIDE STORY

All these parts make up a standard series Torrington Spherical Roller Bearing Pillow Block. What you *can't* see in the illustration is the painstaking engineering that goes into each part.

Housing caps and bases, for example, are doweled in pairs throughout manufacture to insure perfect register. The triple labyrinth seals are designed to avoid rubbing contact. A removable stabilizing ring allows "fixed" or "float" operation. The Torrington Self-Aligning Spherical Roller Bearing provides top operating efficiency even under heavy load and misalignment.

Do you have a pillow block problem? It pays to investigate the outstanding performance and long service life of the Torrington Spherical Roller Bearing Pillow Block. Call or write us today.



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- ☐ Split housing for easy installation and inspection
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- ☐ Standard or heavy duty series available
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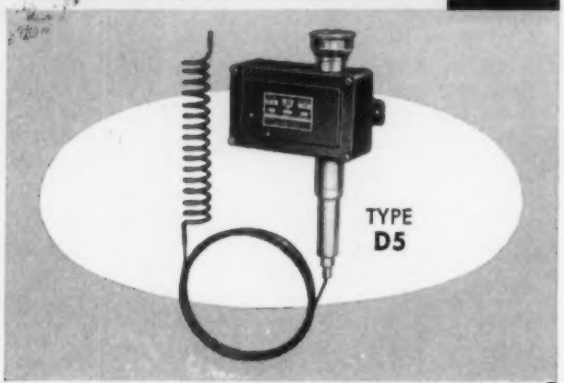
CIRCLE 107 ON READER SERVICE CARD 107

MICROMETER-ADJUSTED

REMOTE BULB TEMPERATURE CONTROL D5



UNITED ELECTRIC's Type D5 Remote Bulb Temperature Control is a precision unit containing a micrometer adjustment for obtaining wide ranges and accurate temperature settings. This control has found extensive use in applications such as laboratory and industrial ovens, water baths, hot plates, etc.

Temperature Ranges	−150°F. to +200°F., 70°F. to 370°F., 100°F. to 650°F.
Switch Ratings	15 amps at 115 or 230 volts AC. Also 20 amps or DC switches on specification.
Switch Types	N.O., N.C., or Double Throw — no neutral position.
On-Off Differential	Approximately 1.0°F. or 2.0°F. dependent on model.
Adjustment	Three-turn, calibrated knob rotated against graduated barrel. Readings and divisions equally spaced over entire range. Adjustment knob includes calibration screw.
Electrical Connections	Made to internally located terminal block via clearance hole in the enclosure.
Capillary Tube Length	Standard length six feet. Other lengths available.
Enclosure	Die-cast aluminum case with black wrinkle finish. Other finishes available.
Mounting	Control head surface mounted in any position by means of dog ears. May also be flush mounted.

UNITED ELECTRIC *manufactures a complete line of temperature, pressure and vacuum controls. Standard units can be modified or custom-built units made to your specifications. Additional information on temperature controls is available upon request.*

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CONTROLS COMPANY

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*to precisely fabricate parts, seals, and components from selected compounds, and for specific applications only!

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NU-CUP has a 42% sharper point which penetrates in a deep, full circle giving tremendous holding power. In some cases it actually reduces the number of set screws needed for the job.

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SETKO Set Screw & Mfg. Co. 153 Main St. Bartlett, Ill. 574R

*U.S. Pat No. 2,778,265

fer at high temperatures conducted with thin-film resistance thermometers, it was found that the presence of even very small degrees of ionization in the shocked gas was sufficient to induce spurious electrical signals in the output of the thin-film gauge. This paper discusses the techniques employed in overcoming this difficulty.

"Thin-film Thermometer Measurements in Partially Ionized Shock-tube Flows," by P. V. Marrone, R. A. Hartunian, Physics of Fluids, American Institute of Physics, 335 E. 45 St., New York.

Shaft Design

To date, most shafts have been designed for one stress, which usually results in excess service life. In the automatic transmission field particularly, new designs are required to transmit more power within the same or even smaller housings. To meet these requirements, the engineer must either do excessive preliminary testing on prototypes (which is usually not done), or have background data on various shafts in the form of S/N curves and service conditions.

This article describes an attempt to simplify the procedure for shaft design. Although developed primarily for steel shafts loaded in pure torsion, similar methods can be applied for bending or combined bending and torsion.

"Shaft Design for Finite Life," by P. E. Burke, Borg-Warner Corp. SAE Paper 359D, Society of Automotive Engineers, 485 Lexington Ave, New York 17.

CATALOGS AND BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover.

SPEED REDUCERS—Catalog 42C, 24 pp. Covers right-angle, spiral bevel gear units of both horizontal and vertical design and presents formulas for gear speed reducer selection, guide for determining load characteristics of more than 160 applications and step-by-step examples of reducer selection. Specifications, ratings and dimension drawings are provided for single-reduction units with input speeds from 100 to 1750 rpm, ratios from 1:1 to 6:1 and hp capacities from 0.14 to 336. James Gear Mfg. Co, 1140 W Monroe St, Chicago 7.

Circle 350 on Reader Service Card

ROD ENDS AND BEARINGS—Catalog 102, 12 pp. Supplies dimensions, dimension drawings, load ratings and materials available in male and

continued, page 111

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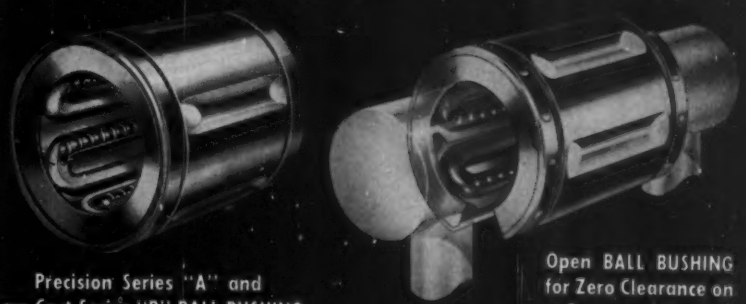
The BALL Bearing for *all* your **LINEAR MOTIONS**



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Sliding linear motions are nearly always troublesome. Thousands of progressive engineers and designers have solved this problem by application of BALL BUSHINGS on *guide rods, reciprocating shafts, push-pull actions,* or for support of *any mechanism that is moved or shifted in a straight line.*

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The various types cover a shaft diameter range of ⅛" to 4". Small sizes available in Stainless Steel. Write for literature and name of our representative in your city.

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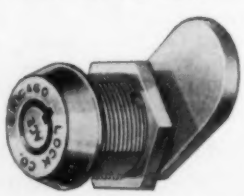

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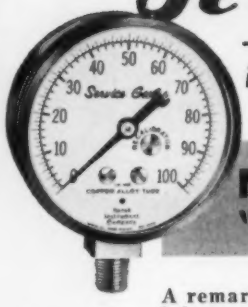

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A remarkable series of 2½" gauges brings you quality, accuracy and stamina —along with REAL economy!

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female rod ends and spherical bearings. Design features are discussed. Split Ballbearing, Div of MPB Inc, Lebanon, NH.

Circle 351 on Reader Service Card

RETAINING RINGS—Catalog 61, price list 61, 24 pp each. Former contains dimension tables, specifications and mechanical drawings of 12 different series. Latter incorporates all revised prices. Industrial Retaining Ring Co, 57 Cordier St, Irvington, NJ.

Circle 352 on Reader Service Card

VARIABLE SPEED BELTS—Bulletin 24103, 20 pp. Contains lists including all known manufacturers of equipment using variable speed belts and belts according to size using new standardized numbering system which conveys width of sheave groove in sixteenths, groove angle in degrees and belt pitch length in inches and tenths. T B Wood's Sons Co, Chambersburg, Penna.

Circle 353 on Reader Service Card

PRESSURE-SENSITIVE TAPES—Booklet DB-56A, 8 pp. Reviews types of tapes available, how they are constructed and factors involved in choosing particular tape for specific application. Johns-Manville, Dutch Brand Div, 22 E 40th St, New York 16.

Circle 354 on Reader Service Card

HYDRAULIC, PNEUMATIC PACKINGS—Bulletin 341, 16 pp. Provides data on cup, flange, U, V packings, O-rings, back-up washers, one-piece double-acting piston cups and double lip shaft wiper seals. Included are information on various materials, conditions of operation, typical design application, specifications, etc. Chicago-Allis Mfg Corp, 125 N Green St, Chicago 7.

Circle 355 on Reader Service Card

HIGH PERMEABILITY ALLOYS—Booklet, 40 pp. Contains data on permeability and core loss of two alloys at both 60 and 400 cps. Also describes new approach to core loss calculations, selection and use of test methods, magnetic behavior of metals and various alloy tests. Tables, graphs and photos of testing equipment are included. Magnetic Metals Co, Hayes Ave at 21st St, Camden, NJ.

Circle 356 on Reader Service Card

DIRECTIONAL CONTROL VALVES—Bulletin 80200-A and 80300-A, 8 and 16 pp. Former covers

continued, page 113

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CLUTCH
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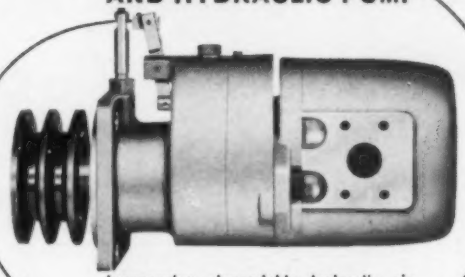

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ELIMINATES NEED FOR PTO

Designed for belt, gear or direct drive

Engagement speeds from idle to 2200 RPM (no load speeds)

Flow rate: 1.7 to 26 GPM

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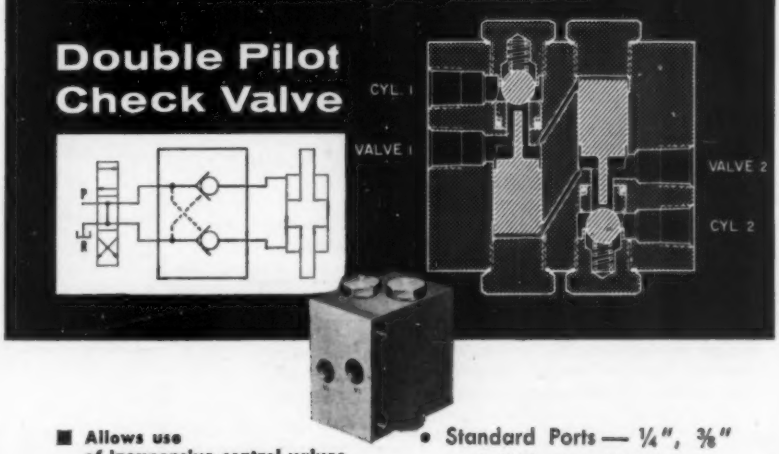

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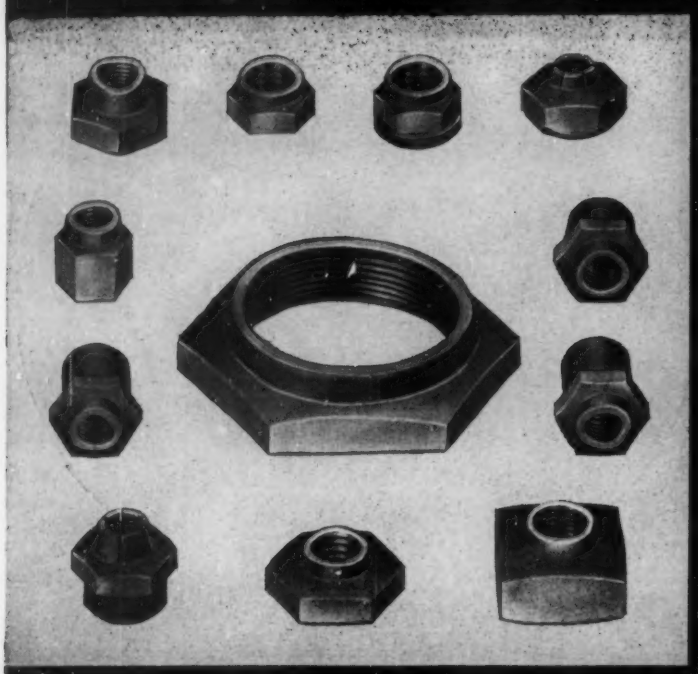
SPECIAL LOCKNUTS . . . *that solved fastening problems*



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  - ☐ Short or narrow?
  - ☐ Concave or convex?
  - ☐ Inside small ID's?
  - ☐ Remotely located?
  - ☐ Of critical importance?
- ☐ Measuring height and width of waves, bows, steps and other widely-spaced irregularities?
- ☐ Measuring individual pits, flaws, scratches?
- ☐ Measuring waviness around surfaces of rotation?
- ☐ Other:_____

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112 CIRCLE 112 ON READER SERVICE CARD

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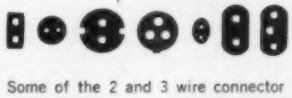

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Often, they yield design advantages, simplify assembly and enhance packaging. **Always,** they make consumer storage easier and cord replacement an over-the-counter convenience. Get more information about detachable cord sets, stock cord set components and custom-engineering services offered by Miller Electric Co.

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CIRCLE 47 ON READER SERVICE CARD

units with 2-way plungers and latter, units with 3- and 4-way plungers. Both carry construction features; dimension, capacity and specification data; flow diagrams; ASA symbols and type designation for all sizes and types of valves. Oilgear Co, 1570 W Pierce St, Milwaukee 4.

Circle 357 on Reader Service Card

SPRING WASHERS—Bulletin SW-2, 8 pp. Describes and illustrates Belleville, arc, 3-wave and other types of spring washers. Specifications are tabulated. George K Garrett Co Inc, Dept SW-2, Torresdale Ave at Tolbut St, Philadelphia 36.

Circle 358 on Reader Service Card

HYDRAULIC CHECKING UNITS—Catalog, 14 pp. Outlines principles of operation, dimensional data, engineering features, typical applications, etc. Also gives details regarding optional equipment which may be installed on units to offer complete automated motion control systems. Pokorny Pow-R-Trol Products Inc, 10643 Memphis Rd, Cleveland 9.

Circle 359 on Reader Service Card

QUICK CONNECTS—Bulletins 240-61 and 250-61, 4 pp each. Former deals with coupling used in high-pressure, gravity flow and vaccum systems, while latter covers coupling used in hydraulic lines. Both review design features, dimensions and parts numbers. Snap-Tite Inc, Union City, Penna.

Circle 360 on Reader Service Card

DIRECTIONAL VALVES—Bulletin 80125, 4 pp. Contains construction features, dimension data and drawings, specifications, flow diagrams, ASA symbols and type designation for all sizes and types of solenoid-operated fluid power pilot valves. Oilgear Co, 1570-V W Pierce St. Milwaukee 4.

Circle 361 on Reader Service Card

TEFLON PARTS—Bulletin R3017, 8 pp. Tabulates properties of molded Teflon and describes and illustrates X-seal rings, O-rings, back-up rings, packings, molded parts, extrusions and machined parts. Allegheny Plastics Inc. Coraopolis, Penna.

Circle 362 on Reader Service Card

GENERAL PURPOSE RELAYS—Booklet, 8 pp. Provides specifications, typical applications and dimension drawings, as well as a "contact arrangements" chart illustrating contact symbols and designations for all basic contact arrangements listed by National Association of Relay Manufacturers. Elgin Advance Relays, Electronics Div, Elgin National Watch Co, 2435 N Naomi St, Burbank, Calif.

Circle 363 on Reader Service Card

TERMINAL PANEL WIRING BLOCK—Folder, 4 pp. Discusses advantages over traditional terminal and barrier boards and sets down specifications and dimensions of various component parts. AMP Inc, Eisenhower Blvd, Harrisburg, Penna.

Circle 364 on Reader Service Card

HYDRO-PNEUMATIC ACCUMULATORS—Brochure, 12 pp. Traces operating principles, designs and uses. Eight basic circuits, utilizing accumulators, are illustrated. Greer Hydraulics Inc, 5930 W Jefferson Blvd, Los Angeles 16.

Circle 365 on Reader Service Card

WOUND ROTOR MOTORS—Bulletin 104, 4 pp. Describes and illustrates construction features of 1- to 30-hp units. Specifications, dimensions and dimension drawings are furnished. Dept P, Louis Allis Co, 427 E Stewart St, Milwaukee.

Circle 366 on Reader Service Card

PRESSURE GAGES—Bulletin 280, 4 pp. Pressure ranges, figure intervals, graduations, connections, dimensions and specifications are given for 3- and 5-in. dial sizes. American-Standard Controls Div, Rochester Instrument Plant, 100 Rockwood St, Rochester 10, NY.

Circle 367 on Reader Service Card

PRESSURE SNUBBERS—Folder, 4 pp. Outlines design features, applications, recommended porosities, pressure ratings, etc. of porous metal pressure snubbers. Scale drawings are included. Chemiquip Co, 36 E 10th St, New York 3.

Circle 368 on Reader Service Card

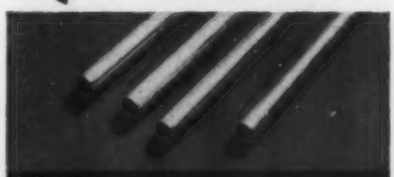
WIRE BRAIDED TEFLON HOSE—Bulletin 29, 4 pp. Reviews features, applications, media, working pressures and dimensions of extruded Teflon tubing with high-strength bronze wire braid sheath. Also covers reusable solid male, male and female union, and JIC swivel fittings. Atlantic Metal Hose Co Inc, 308 Dyckman St, New York 34.

Circle 369 on Reader Service Card

INTEGRAL HP MOTORS—Bulletin L-3314A, 6 pp. Contains selection and specification tables, mounting arrangement drawings, speed-torque

continued, page 117

Q. HOW THIN CAN METAL TUBING WALLS BE?



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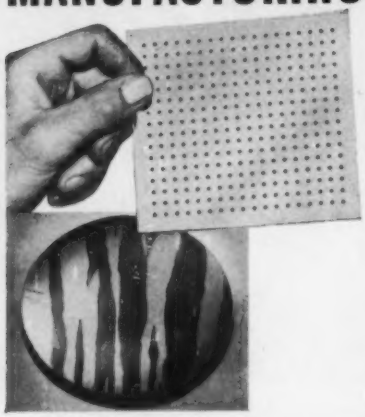

Memory array has (upper) been produced at Remington Rand Univac by deposition of evaporated metal. Photos (lower) are taken in both black and white and color by Univac Research Engineers who have been photographically observing for some time the domain patterns in thin deposited films through the use of the Kerr Magneto Optic Effect.

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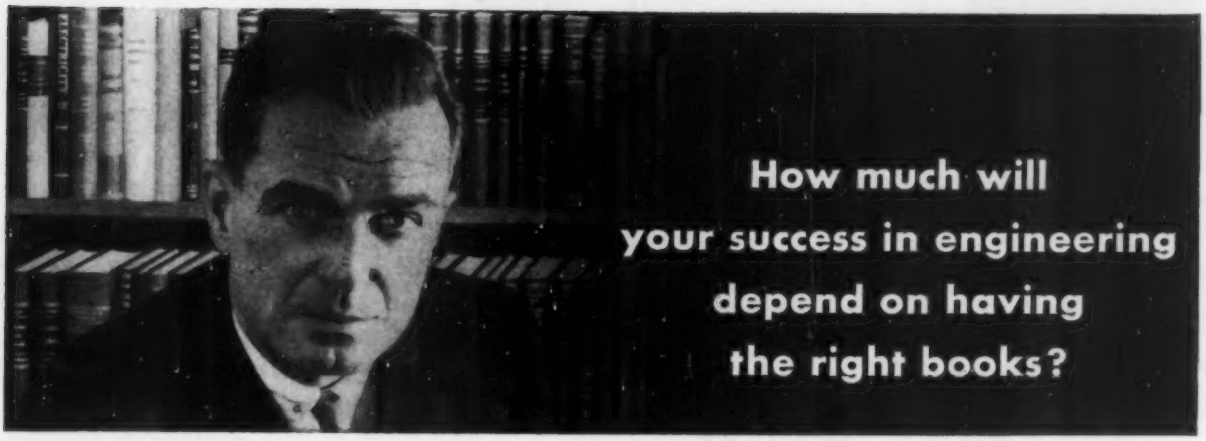

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curves, and principal dimensions of general purpose units. Also pictures a number of special units. Kingston-Conley Inc, Sub of Howell Electric Motors Co, Plainfield, NJ

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ADJUSTMENT POTENTIOMETERS—Brochure 7, 4 pp. Summarizes performance data on 20 basic models, including resistances, power ratings, operating temperatures, etc. Dimensions and prices are supplied, as well as cutaways of 4 models. Bourns Inc, Trimpot Div, 6135 Magnolia Ave, Riverside, Calif.

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O-RING SEAL—Bulletin 1-065, 6 pp. Explains and illustrates reasons for "O" shape, how O-ring works and how seal reacts to pressure. Seals Inc, 393 Central Ave, East Orange, NJ.

Circle 372 on Reader Service Card

AC CAPACITORS—Catalog MS61-10, 16 pp. Reviews capacities and physical dimensions of motor-run, motor-start capacitors. Formulas are given for selection of proper units. Aerovox Corp, New Bedford, Mass.

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URETHANE HYDRAULIC COMPONENTS—Data sheets, 2 pp each. One covers physical characteristics, sizes and dimensions of urethane rod wiper/scrapers, while other deals with sizes and types of urethane O-rings. Disogrin Industries, Div of Pellon Corp, 510 S Fulton Ave, Mt Vernon, NY.

Circle 374 on Reader Service Card

BERYLLIUM COPPER ROD—Bulletin R-1200-A, 8 pp. Covers alloys and sizes, giving data on tensile strength, yield strength, elongation, Rockwell hardness, electrical conductivity and other properties of three alloys. Nominal composition, specifications for ordering and tables for selection of proper alloy are included. Beryllium Corp, Reading, Penna.

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Answers to problems on page 94

Ans: $x^2 + cx$

Ans: $K \cos x$

Ans: $K \left(\frac{\sqrt{3x^2 + 4} - 2}{x}\right)^{3/2}$

Ans: $\frac{x^4 + 2x^2 + c}{4(x^2 + 1)}$

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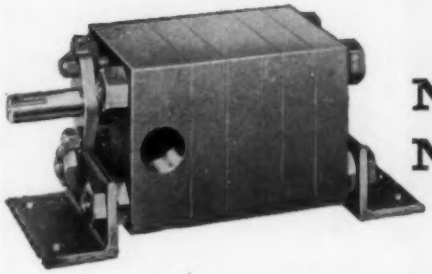

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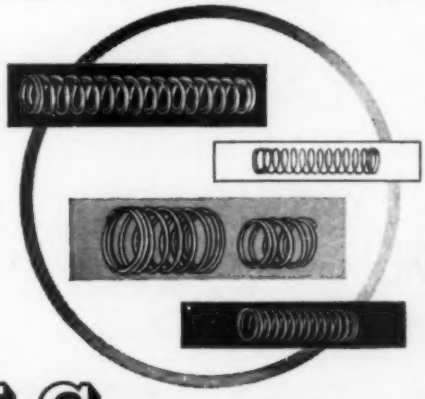

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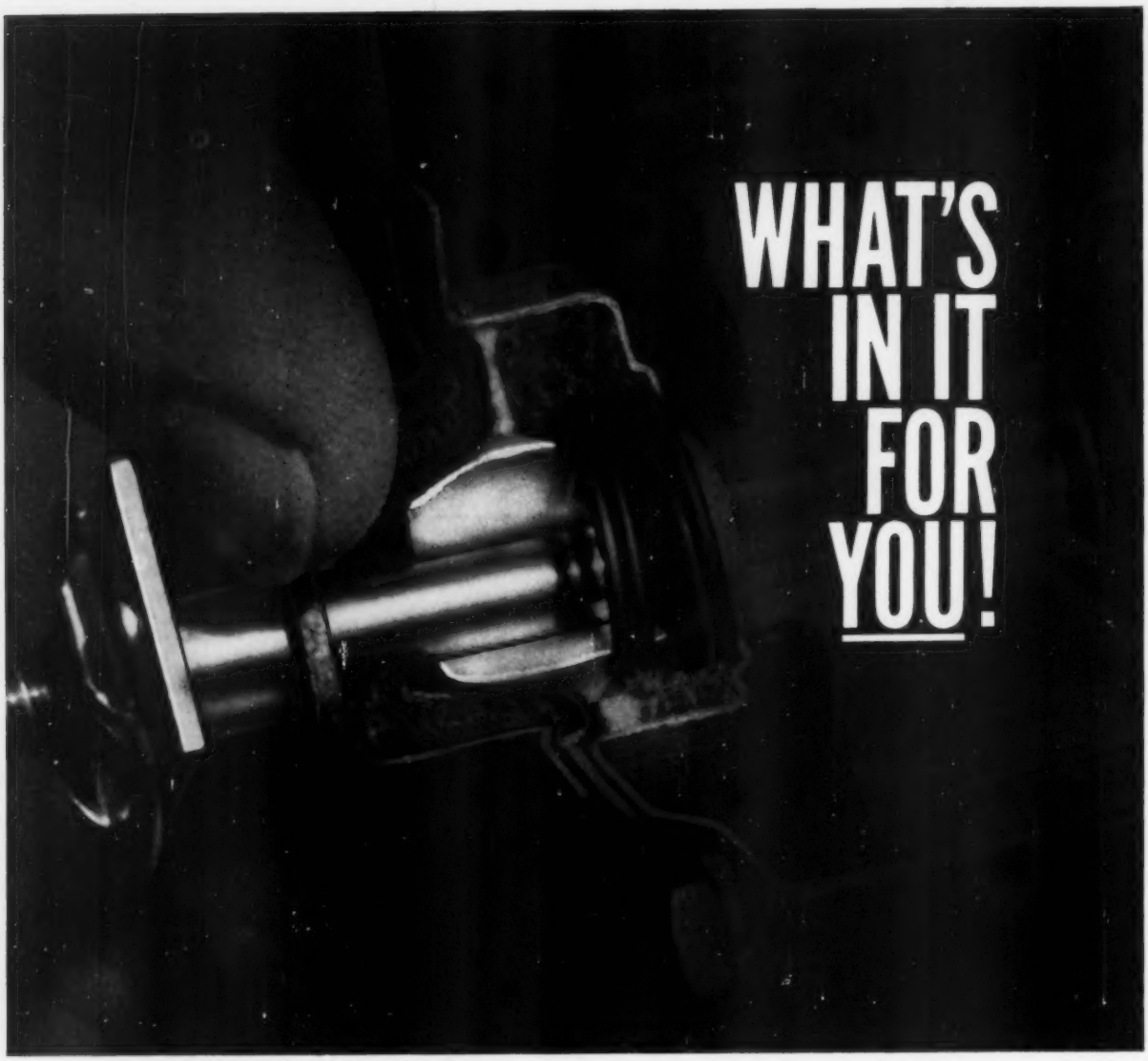

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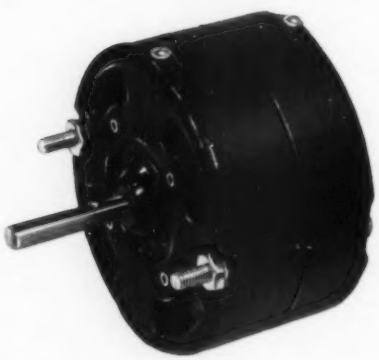

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